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TAPPING A MODERN BLAST FURNACE

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ETHICS OF MONOPOLY

A MODERN national economy is a complex mechanism; it would be very surprising if it always ran smoothly and efficiently. Thus it is necessary occasionally to take stock and put things right if they are wrong. One approach is the official inquiry, and the recent Monopolies Commission Report on the Supply and Exports of Electrical and Allied Machinery and Plant illustrates the manner in which this safeguard is applied in Britain. But sometimes there are cases—and the present report is possibly an example—when the questioners themselves might usefully be questioned.

Price fixing is regarded as a commercial misdemeanour, perhaps rightly; but surely its ethical standing depends on its consequences, which may be good or evil. Power is not wrong in itself, only its abuse. It was the way Marie Lloyd sang "Come into the Garden Maud," not its content, that brought her before the watch committee. The electrical manufacturers feel that their position has not been adequately stated and that progress in electrical plant design—which is largely the result of their enterprise in costly research and development—may well depend on some degree of price fixing. Thus only the clairvoyant could estimate accurately the manufacturing cost of a 200 MW generator set or a nuclear power station, since no experience of either as yet exists; and unless a manufacturer has some margin of security he cannot be expected to undertake such a costly and uncertain project. The result would be stagnation.

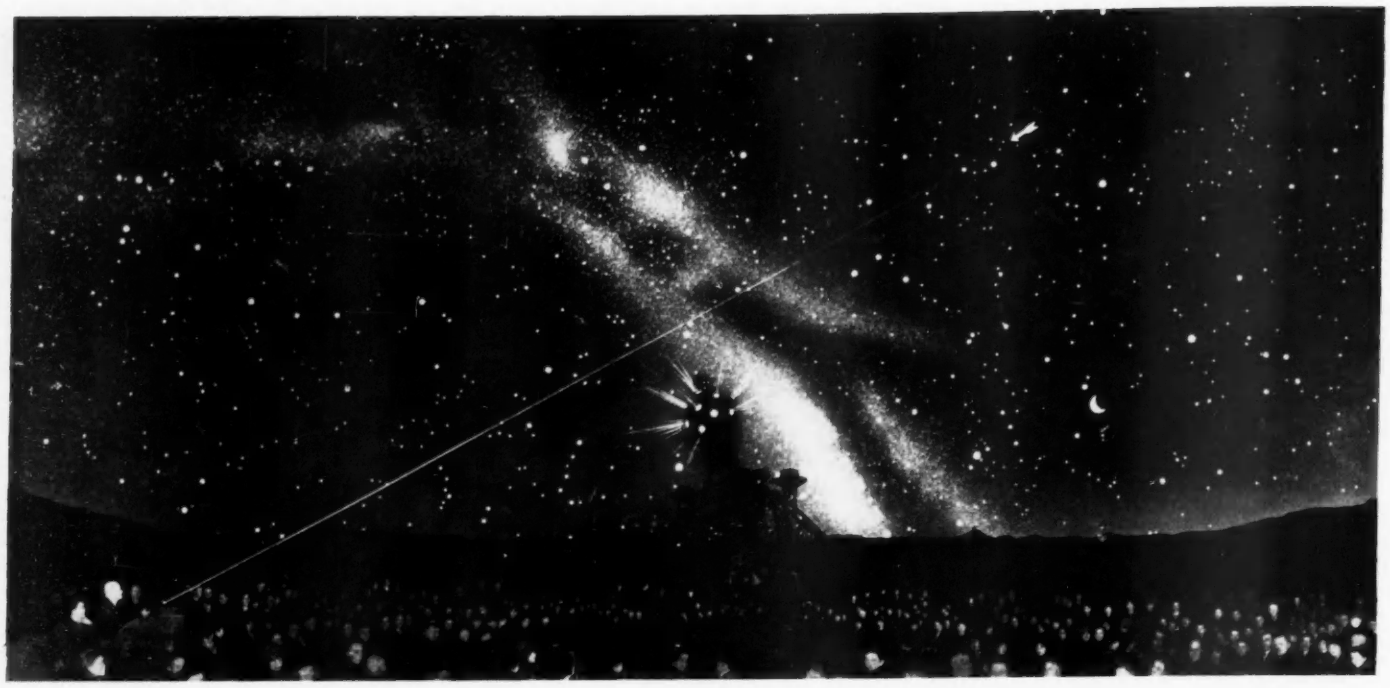
In any case, say the manufacturers, in selling to a monopoly buyer such as the Central Electricity Authority, co-operative measures are a necessary self-defence. Negotiation with the C.E.A. has always been amicable, but their power in terms of guaranteed quota and prerogative to select the products of a particular manufacturer represents a real danger. Consider the beam in your own eye, the British electrical manufacturers have answered in effect. It is notable that other products made by the same companies—cookers and washing machines, for example—are not subject to price agreements. The companies concerned are also anxious about the effect of the report on potential overseas buyers; it is surely, they say, in the national interest to retain their prestige in the export market, and unfavourable comment may prejudice their chances. But there is another side too: the report argues that export sales are indirectly subsidised by sales in the home market. This revelation is hardly likely to discourage overseas customers.

There is probably much more to be said on the subject. Perhaps a wider representation of industrialists on the Commission might have lent greater realism to the inquiry and more confidence in the conclusions. The manufacturers feel—and this is where confidence is important—that it is difficult to explain technical matters to a non-technical body, whether or not some of its members have an engineering background. It is significant that the one member dissenting from the Commission's criticism of the common price system was an industrialist. Possibly, too, it would be better if the party which is virtually attacked had the opportunity—as is the tradition in English law—to cross-examine hostile witnesses. The cost of an extensive report of this kind must be very high, even without allowing for the indirect expense incurred by the industry. It is reasonable to ask: what benefit does the inquiry yield? And is the result commensurate with the cost.

Competition is no doubt desirable but should not be regarded as an end in itself, for though it provides the incentive it may also deny the means. Thus, although a firm may be driven to make every effort, the price war may leave no surplus for investment in research. Research on electrical plant and machinery is an investment—for the good of the country as much as the industry—which is inevitably of a long-term character. Competition is also a matter of scale. The resources of a nation may not stretch to more than one manufacturer in the case of certain large-scale products. Are we then to retire from the field, leaving it entirely to the giant economies of America and the Soviet Union? Indeed, the Government have themselves encouraged the formation of consortia for the building of nuclear power stations, and have found that the number of groups British industry can support is smaller than anticipated. There is also the familiar argument that without price fixing the weaker competitors may go to the wall, leading to more monopoly not less.

Nevertheless, without a proper system of checks and balances, of which the Monopoly Commission Report is a British example, an industrial state would be exposed to many abuses. This country is, in fact, happily free from corruption; we must acknowledge our debt to the ethical tradition we have inherited. Ethics is a study of some subtlety, on which no final statement is possible. But we should surely be safe in assuming that monopoly and competition are morally neutral; only their consequences can be judged. To Major Barbara, armament manufacture was an unmitigated evil, until she saw the workers' paradise that armament profits had provided.

MOVING PICTURE OF THE UNIVERSE



Interior of a Zeiss planetarium. Images of stars, nebulae, planets and the Milky Way are projected on the inside of a dome and their apparent movements reproduced by the action of the projectors.

Plain Words

Whenever Parliament debates the troubles of the motor industry, as it did last week, some Member is sure to call for more standardisation, citing the American industry as an example to follow. Such thinking seems to be based on nostalgic memories of the Model T Ford, but has little in common with the present bewildering variety of models now produced in Detroit to tempt the pampered American public.

Chevrolet alone make 20 models—saloons, hardtops, convertibles and station wagons, with two or four doors and from six to nine seats. There is a choice of four different engines and four transmissions, including two different types of fully automatic transmission, and enough choice of colour schemes to produce 460 different cars. The Ford range comprises 19 models with four sizes of engine and three transmissions. And these are only part of the vast ranges produced by General Motors and Ford.

Yet the American industry only has to produce one basic size of car, a large, luxurious 100 m.p.h. model. The British industry caters for the full range, from little economy models for the heavily taxed and car-starved home market, to sports cars and powerful closed models for overseas. Even so, the B.M.C. make do with three engines for 23 car models of six makes, and a large range of light commercial vehicles. Eleven closed cars of five makes are obtained from four sets of basic body pressings. Rootes get five open and convertible models of three makes out of one basic structure, and two engines. It is a pity that before advertising foreign products some of the British industry's critics cannot take the trouble to be better informed on the efforts it makes.

ZEISS PLANETARIUM FOR LONDON

By H. C. King, PH.D., M.SC., F.B.O.A., F.R.A.S.*

To a spectator on the earth, the stars and planets appear to move so slowly that sudy of their motion is impossible without long and patient observation. The movements of the planets are particularly difficult to interpret and in fact remained inexplicable to many generations of astronomers; indeed the Greek name by which they are still known means wanderer. Understanding the heavens would certainly have been much simpler if man had been in a position to increase the speed of celestial movement, to stop it at will, or to turn it back, but that was beyond the scope of even the best astronomers. To provide a more amenable firmament, Dr. W. Bauersfeld, of the German company Carl Zeiss, devised an artificial universe in which light images corresponding to stars, planets and other astronomical phenomena were projected on the inside of a large dome. Such a planetarium is now being built for Madame Tussaud's Limited on a site adjacent to the famous Waxworks in Marylebone-road, London; the projection equipment, costing about £50,000, is being made by Carl Zeiss of Oberkochen, Western Germany. The equipment involves interesting optical and mechanical problems, since the apparent relative motion of stars and planets is necessarily complex. In this article Dr. King discusses the operation of the projectors and the means by which the itinerant features of the night sky are reproduced.

In March, 1919, Dr. W. Bauersfeld, who recently celebrated the 50th anniversary of his entering the firm of Carl Zeiss, began to explore the possibilities of forming images of the stars and planets on the inner surface of a large hemispherical dome by means of a massed array of central projectors. The optical units were to be movable, and so disposed and inter-related through linkages and gear-trains as to be capable of reproducing not only the diurnal motion of the stars but also the individual apparent motions of the sun, moon and planets. Five years later, the first Zeiss optical planetarium was set up on the roof of the Zeiss works at Jena. Public interest was immediate and gratifying. During the period August, 1924, to January, 1926, some 80,000 visitors viewed the artificial heavens. The instrument was thereafter operated at the Deutsches Museum, Munich, and a second projector, subsequently moved to the Haag'sche Courant at The Hague, took its place.

FIXED AND VARIABLE LATITUDE

These two projectors, both still in operation and with the one at Munich in its original form, are of the fixed-latitude type. Some idea of their general layout is shown in a drawing on page 259. The globe or " star carrier " of 50 cm. diameter contains 31 optical projectors and a central 200 watt lamp for the reproduction of stars from the first to the sixth magnitude. As the electric motor (M) is operated, star images travel over the surface of the dome and simulate in a few minutes the appearances due to the earth's diurnal rotation. Beneath the globe, a " planetary framework " with seven compartments or " cages " contains projectors for forming images of the sun, moon and the five planets known since antiquity. The globe, it will be noticed, rotates on a polar axis fixed for one particular latitude—that of Munich, about 42 deg.

In 1926, and as a result of the inventive talent of Dr. Walter Villiger, Zeiss introduced a more versatile composite projector. This represented the night sky for all possible geographical latitudes, and with its numerous additions and improvements rightly merited the designation " universal instrument." Projectors found in large planetarium installations the world over (with the exception of England) are of this type. Financial considerations and difficulties over the choice of a suitable site seem to have been responsible for the failure of various schemes to erect a planetarium in London. Fortunately, about two years ago, the directors of Madame Tussaud's Limited thought fit to build a planetarium on the bombed site adjoining the famous

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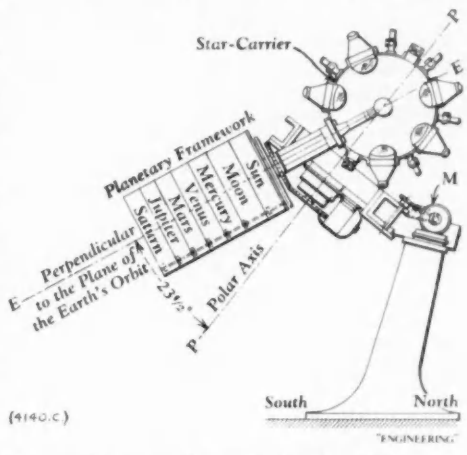
waxworks in Marylebone-road. The projector now nears completion in the Zeiss works at Oberkochen, while work on the building is making good progress.

DUMB-BELL PROJECTOR

The Zeiss projector for Tussauds differs only in detail from its predecessors, the last one of which left Oberkochen in 1953 to display its artificial sky in Sao Paulo, Brazil. It takes the form of a large dumb-bell about 4 m. long which is supported by a frame or carriage built of thin steel bars. The entire instrument weighs about 2,500 kg. By arranging the projectors symmetrically in the dumb-bell, balanced movements can be obtained without recourse to heavy counterpoises. Also important is the fact that the dumb-bell can be rotated about a horizontal east-to-west axis (E-W in the drawing at the top page 260) to produce appearances which correspond to those seen from different geographical latitudes. This is illustrated in a diagram on the right of this page. There are two further degrees of freedom. Rotation about the polar axis (P*n*-P*s*) reproduces the diurnal motion, while the remaining motion, about the axis (Q*n*-Q*s*), reproduces the precession of the equinoxes, or the slow movement of the celestial pole about the pole of the ecliptic. In nature the precessional cycle takes 25,800 years, but in the planetarium it is reduced to 1 minute 16 seconds. These motions are uniform and are electrically controlled from the central panel at the demonstrator's desk.

The two star globes, each 75 cm. in diameter, provide some 9,000 stars for both hemispheres. All stars of the second magnitude and fainter are formed by 32 f/4·5 Tessar-type projection lenses. In pre-war instruments the brightest stars (with the exception of Sirius) and the faintest stars were all projected from perforated copper-foil plates. The holes in these foils had about 65 different sizes and produced images which were correctly graded and orientated *inter se*. A disadvantage was that the brightest stars were represented by large discs, and although these were not objectionable for observers seated near the centre of the dome, their very size (about 4 cm. for a dome of 20 m. diameter) and frequent foreshortening for observers near the dome surface detracted from the otherwise realistic effect. In the projectors for Sao Paulo and London, however, 42 special supplementary projectors fitted on both sides of the instrument (between the star globes and planetary frameworks) project images for the 42 brightest stars in both hemispheres. The diameters of these images are no greater than those of the old-type "perforated" stars of the second magnitude. Furthermore, the 32 star plates which provide the remaining stars are now produced by photochemical means on plates which are both scratch-proof and stable under tropical conditions. By using these improved plates, in conjunction with coated lenses of high light transmissivity, the star-studded sky of the planetarium is of remarkable brilliance. Even so, and in order to simulate the effects due to atmospheric absorption, the brightness of these stars must be gradually reduced as they approach the planetarium horizon. This is done by mounting a gravity-controlled occulting device in front of each projector, thereby reducing the emergent light flux as each lens approaches the horizon.



Two early geocentric projection planetaria were of fixed-latitude design, so that the sky appeared as seen from one latitude only.

MOSAIC OF SEPARATE FIELDS

Since the starry firmament is reproduced by a mosaic of 32 separate fields, each projector projects a pentagonal or hexagonal shaped

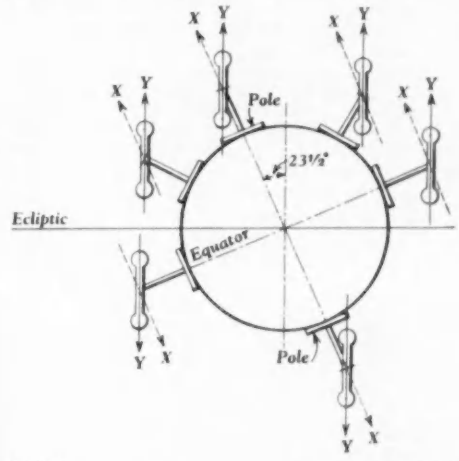
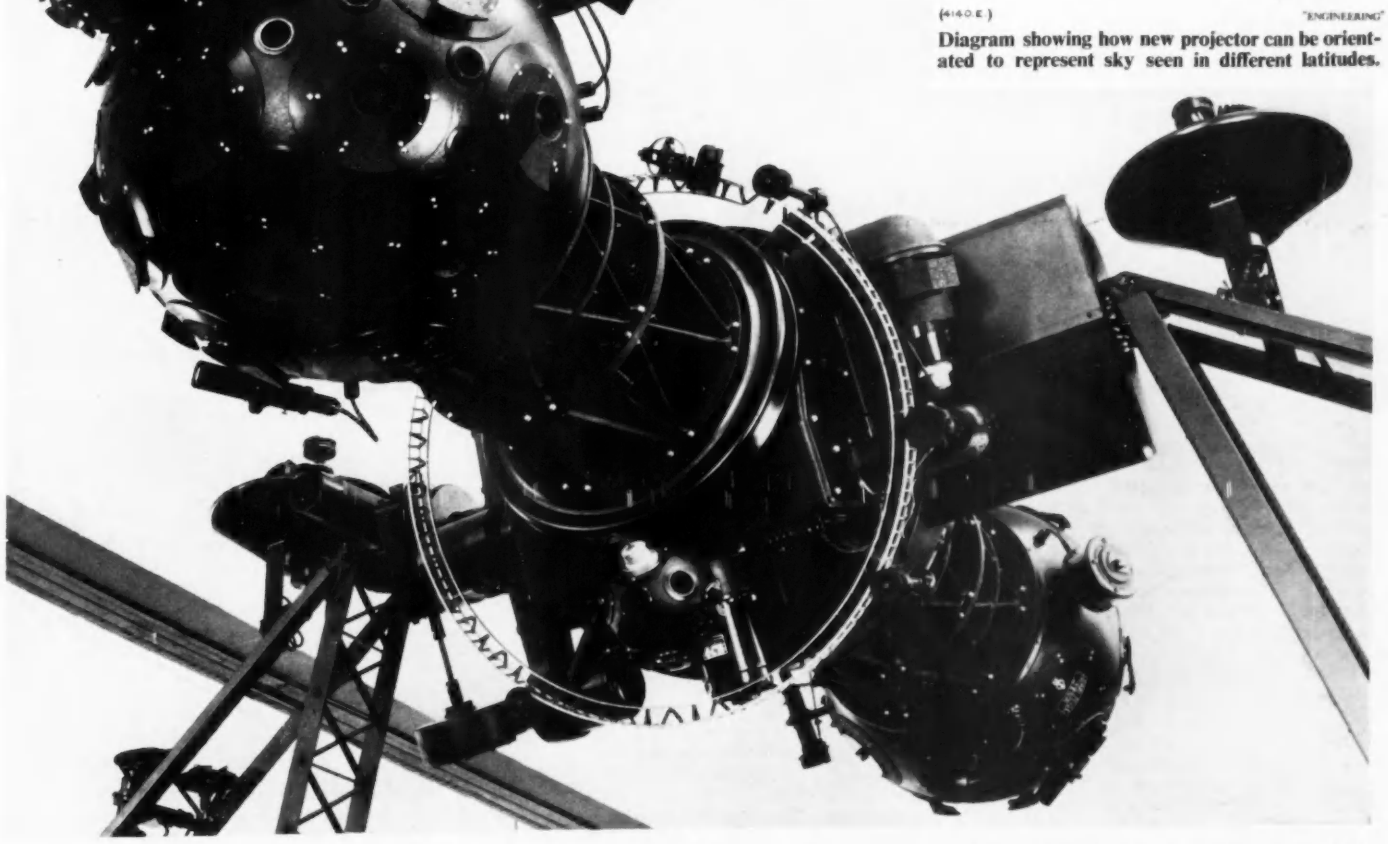
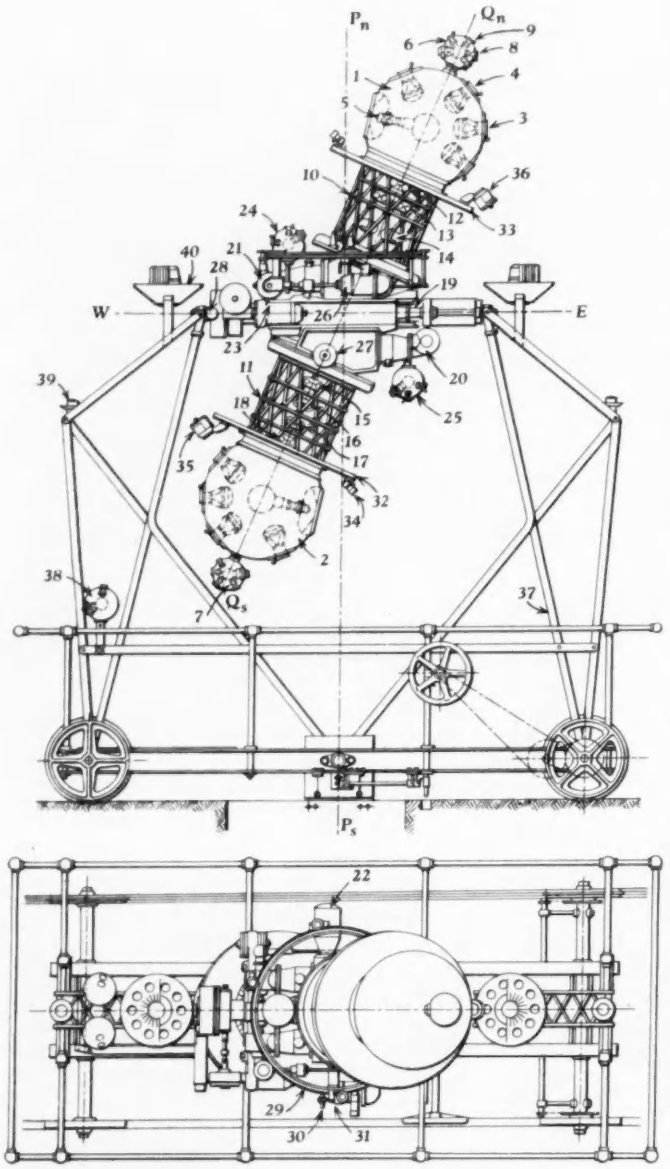


Diagram showing how new projector can be orientated to represent sky seen in different latitudes.



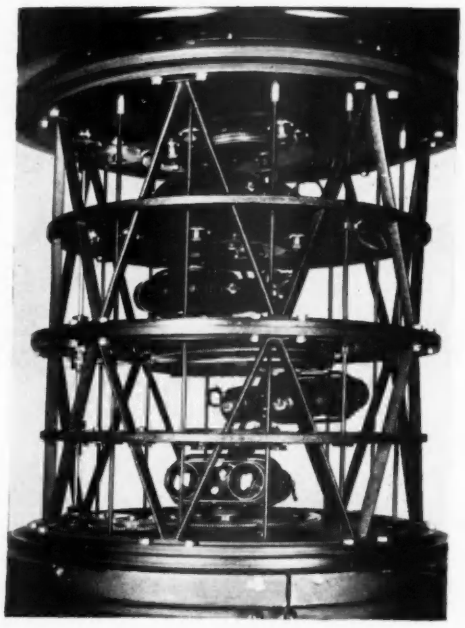
Close-up view of projector. Each projection head is in the form of a 32 sided solid so that the starry firmament is reproduced by a mosaic of 32 separate fields.



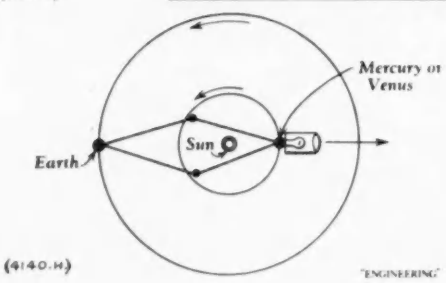
The sky as it appears from any desired latitude can be reproduced by means of a modern dumb-bell projector, which may depict as many as 9,000 stars in both hemispheres.

(1 and 2) Two fixed star globes
(3) Projectors, 16 per globe
(4) Mechanical shutters, 16 per globe
(5) 1,000 watt lamp, one per globe
(6 and 7) Two globes for constellation names and precession dial
(8) Projectors, 15 per globe
(9) Mechanical shutters, 15 per globe
(10 and 11) Two planetary frameworks with double projectors and planetary mechanisms
(12) Mechanism for Saturn
(13) Mechanism for Sun with aureole
(14) Mechanism for Moon
(15) Mechanism for Mercury
(16) Mechanism for Venus
(17) Mechanism for Mars
(18) Mechanism for Jupiter
(19) Centre piece on cradle
(20) Two motors for diurnal movement
(21) Three motors for annual movement
(22) One motor for precessional movement
(23) One motor for polar altitude variation
(24 and 25) Two globes with 6 projectors each for equatorial grid reference system and ecliptic, and for two pole arrows
(26) Projector for year counter
(27) Mechanical precession counter
(28) Optical polar altitude reader
(29) Lattice ring
(30) Vertical circle projector
(31) Hour circle projector
(Above three items comprise equipment for demonstrating the mean sun and the nautical triangle)
(32 and 33) Two ruffs between fixed-star sphere and planetary framework
(34) 45 special projectors for the 42 brightest fixed stars and the three variable stars Algol, Mira Ceti, Delta Cephei
(35 and 36) Two Milky-Way projectors
(37) Carriage frame
(38) Two spheres with two projectors each for meridian
(39) Two horizon illuminations for morning and evening
(40) Two dome illuminations providing white and blue light

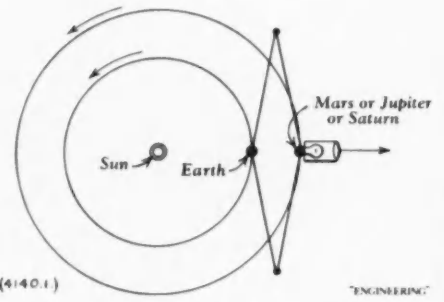
Close-up view of projector, showing inside of fixed-star sphere with three of 16 aspherical condenser lenses.



Projectors for planets.



(a)



(b)

Mechanical linkages for an inferior planet (a), and a superior planet (b).

portion of the sky. The star-field projectors are therefore mounted in effect on the faces of a regular icosahedron the twelve corners of which have been cut away to give a 32 sided solid. In addition, due allowance has to be made for the parallactic displacement occasioned by the non-concentricity of the surfaces of the star globes with the dome. It will be appreciated that quite apart from the immense problems of design and manufacture, the final adjustments of over 100 star projectors is a matter of considerable delicacy.

The star globes also carry projectors for special objects—the Magellanic Clouds, special nebulae, globular star clusters, and the variable stars *Algol*, *Mira Ceti* and *Delta Cephei*. Small globes at the extremities of the dumb-bell between them carry thirty projectors for the constellation figures and for which approximately 300 diapositives are available. Thus observers in a planetarium can see how the Babylonians, Egyptians, Greeks, Arabians, Chinese, Malays, and others, interpreted the various star groupings. The Milky Way is projected by two drum-type projectors, one at the side of each star globe. This feature of the night sky is non-uniform both in width and brightness, yet its representation in the planetarium is most realistic. A drawing of the Milky Way was first made by stippling of proper intensity on a white paper negative. This drawing was then photographed on a film wrapped round to form the curved surface of a cylinder. Satisfactory occulting for that part of the Milky Way below the horizon is effected by half filling each cylinder with mercury. Further sets of projectors (24 and 25 in the drawing above) give the main parts of the grid system with reference either to the celestial equator (declination and right ascension) or to the ecliptic (celestial latitude and longitude), while projectors (38) on the main frame throw the meridian on the artificial sky.

COMPOUND PLANETARY MOTION

The movable projectors for the sun, moon and planets are housed in the cylindrical frame-section of the dumb-bell. Those for Saturn, the sun and the moon occupy the upper cage, those for Mercury, Venus, Mars and Jupiter occupy the southern cage. The projectors are all doubled and of large aperture, for the struts of the cages, although thin like those of the carriage, would otherwise cause appreciable dimming. The paired projectors are aligned to produce a single image. The sun cage is generally equipped with five extra projectors. Two give rise to a halo or aureole of diffuse light centred on the sun, thereby simulating the sky glow seen at sunrise and at sunset. A single projector throws the semblance of the lens-shaped zodiacal light to some distance on either side of the sun. Lastly, a paired projector produces the *Gegenschein* or counter glow—a nebulous patch of light seen among those stars diametrically opposite to the position of the sun. To heighten the interest the planets are projected with sizeable discs. The image of Mars is red, Jupiter appears with belts and Saturn with rings. Mercury and Venus do not show phases but are distinguishable by size. The phases of the moon are shown by

means of a projector which incorporates a concave mirror about which rotates a closely fitting hemispherical cup. The cup rotates on its axis in one synodic month and its projected edge gives rise to the moon's terminator. A recent improvement is the showing of the markings of the moon's surface (maculae), for hitherto the planetarium moon had a featureless disc.

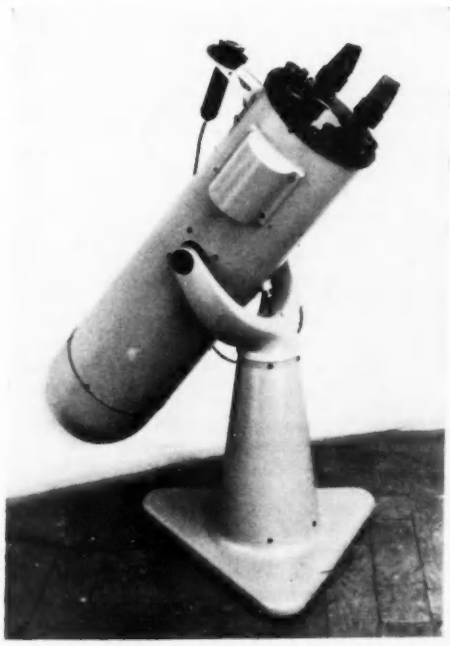
In nature we see the planets from a moving earth; hence their apparent geocentric motions are a combination of their own motions and that of the earth about the sun. In addition, their orbits are variously inclined to the ecliptic and they all appear to participate in the East-to-West diurnal motion. Relative to the fixed stars, therefore, the planets are seen to trace quite complex paths. They advance in right ascension, become stationary, and then regress, moving in pendulations and loops which lie in the vicinity of the ecliptic. In this plane the sun appears to make its annual journey, and with a motion that is by no means uniform (owing to the ellipticity of its orbit). To demonstrate these geocentric motions the axis of the planetary framework ($Qn - Qs$ in the upper drawing on page 260) must be inclined at a constant angle of $23\frac{1}{2}$ deg. to the polar axis ($Pn - Ps$). A driving shaft gives a common diurnal motion to the individual planet mechanisms but on this basis, and even at the maximum speed of one day in 3 minutes (for the London instrument), it would take the planetarium sun over 18 hours to trace out its annual path along the ecliptic. In order to obtain an idea of the complex solar, lunar and planetary movements over several years, it is therefore necessary to drive the associated projectors independently by three motors which run single or together in the same or in opposite directions. In this way the events in a year can be reduced to the compass of 12 minutes at maximum or 10 seconds at minimum. The mechanical linkages for inferior and superior planets are shown in the drawings at the foot of page 260.

To produce all the vicissitudes that the non-commensurable periods, non-uniform motions, and different orbital inclinations introduce into the behaviour of the planets, ingenious adaptations of uniform circular motions are employed. The most elaborate systems of offset circles pertain to the projectors for Mercury and Mars, for these planets have comparatively high orbital eccentricities. It is claimed that at any given moment a planet appears in the planetarium sky only a degree or so from its true position in the natural sky—a remarkably small departure by the standards of ordinary naked-eye observation. Equally important are the various mandatory although not necessarily reciprocal interconnections for the motions of all parts of the projector. Thus although the annual and precessional motions operate automatically when the diurnal motion is on, they can be operated by themselves but always together. The annual motion always requires an associated precessional motion, but the reverse is not the case. In the light of these and many other mechanical requirements it is small wonder that Bauersfeld covered 600 folio sheets with basic astonomical and technical calculations for the Munich fixed-latitude instrument alone.

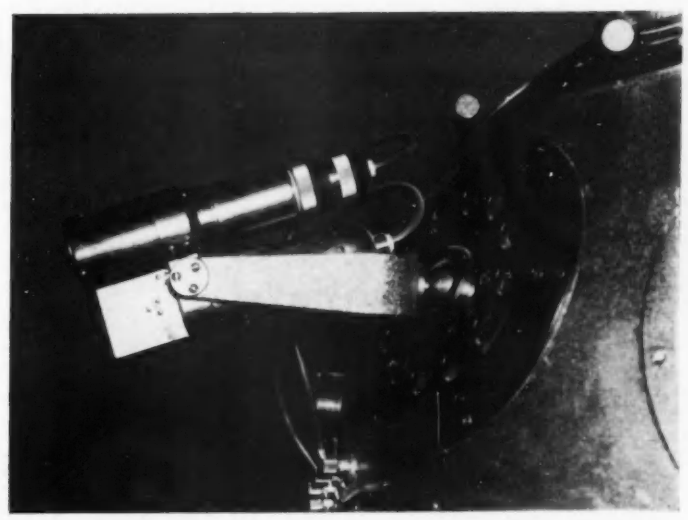
The design of a planetarium dome 20 metres in diameter involves problems in optics, acoustics and ventilation. Stretched white linen has proved a satisfactory material in many cases, a lower shaped-steel margin being added to represent the actual skyline. If the dome is of painted steel (as at Philadelphia and Pittsburgh) or aluminium (as at Paris), the surface is perforated with small holes to prevent objectionable echoes. The holes are only just over 1 mm. in diameter and do not interfere with the projected star images. The silhouette of the local horizon is in all cases a cut-out at the base of the dome. Here the light passes beyond the confines of the dome to strike an inclined black screen, and the illusion is complete.

A LIFETIME IN AN HOUR

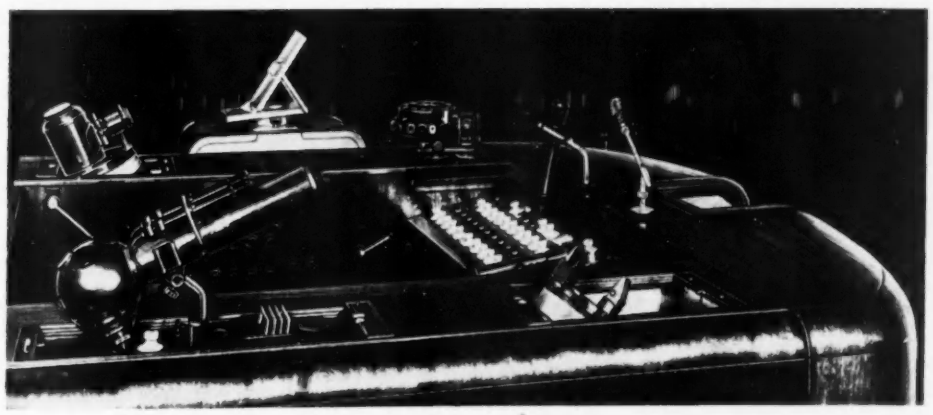
Anyone who visits a planetarium solely expecting entertainment is usually disappointed. It is entertaining, of course, to have the novelties of so bright a firmament introduced in this dramatic way. A popular feature is the appearance of the heavens (but ignoring the contour of the skyline) at the time of any great event in recorded history, or for some prehistoric or future epoch. But celestial objects are unusual actors, and the geocentric viewpoint of the observer is at once natural and disadvantageous. Without a knowledge of near-circular orbits and their relative dispositions in space, the viewer (like the Babylonians of old) finds the advances, stationary points and retrogressions of the planets almost incomprehensible. If these appearances taxed the geometrical ingenuity of Eudoxus, Hipparchus and Ptolemy, how much more obscure must they appear to the lay mind of to-day. Nor is the understanding necessarily assisted by condensing the results of centuries of patient naked-eye observation into the compass of an hour. Yet planetary motions are but one feature given by the versatile Zeiss projector. There are, in addition, such subtleties as the effects of precession and nutation, and the apparent motions and eclipse cycles of the sun and moon.



(Left) Solar system projector, for showing planets rotating about a stationary sun. The motion is thus heliocentric and not geocentric as in the main projection system.



(Right) Comet projector.



Switch and lecture desk, showing projector for solar and lunar eclipses (foreground left) and constellation projector (rear right). A light-beam pointer (see opening illustration) is also provided.

Those who regard a planetarium as "a schoolroom under the vault of heaven" (to use the words of Dr. E. Strömgren), who seek knowledge rather than entertainment, find that it fully meets every demand. The observer can see more in an hour than he might otherwise see in a lifetime. For the first time, perhaps, he learns something of the drama of the skies—something of the plan and order that underlie astronomical events. Through the planetarium the confines of general knowledge are rapidly extended to embrace both planets and stars. Human trials and endeavours are contrasted with the serene but impersonal cosmic background. The spectacle is at once realistic, dynamic and inspiring.

Acknowledgment

Grateful acknowledgment is due to Mr. A. H. Degenhardt, London representative of Carl Zeiss, for providing technical information, and to Carl Zeiss, Oberkochen, and *Discovery*, for the illustrations.

Weekly Survey

Cover Picture: *The lower portion of the stack of a modern blast furnace is encased in a cast house and, when ready for casting, the tap-hole of the furnace is pierced by means of a compressed-air drill. The molten iron is led into large 60-70 ton hot-metal ladles. The tap-hole is subsequently closed by means of a clay gun, usually of the piston type, which is swung into position from its place alongside the tap-hole.*

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The New Dominion

On March 6 the new Dominion of Ghana will come into existence within the British Commonwealth. It will be the first African Dominion to run its affairs without a dominant white population. Its relations with the United Kingdom are likely to be good, though allowance must be made for the natural urge to exercise its complete authority over its own affairs in some startling and perhaps even petty ways. A report by the F.B.I. some time ago warned against a too optimistic attitude on the part of those who would invest in new enterprises in British West Africa which includes the Gold Coast shortly to be called Ghana. It is of course true that relations between the local population and the big trading companies, of which the United Africa Company is outstanding, have not always been cordial, but much of the prejudice against them on the part of the Africans has been based on ignorance and envy. There is no doubt that opportunities for British enterprise and engineering contracts will exist in the new state.

The prosperity of Ghana will depend primarily on the cocoa industry as it has done for about 40 years. At the moment the purchasing power of the community and the state of the Exchequer are dependent on the world price of cocoa. State marketing boards are a fashionable device in West Africa for insulating the peasant farmers from the full impact of changes in world prices but the insulation can never be more than partially effective. Other exports of significance are gold, manganese, diamonds and timber. In the past the road system, the harbours, the public utilities and the social services have been built out of cocoa. The main hope that this serious dependence on one volatile commodity will be significantly reduced depends on the Volta River project. This is still under examination in some of its aspects. It involves the investment of £230 million in a hydro-electric scheme for the local aluminium industry. The expenditure is shared between the Gold Coast Government, the United Kingdom Government and the United Kingdom and Canadian aluminium interests. This project is now in hand to some extent and the harbour at Tema, to mention only one undertaking, has been put out to contract to the advantage of British civil engineers. Contracts for new railway and road facilities as well as all the electrical engineering equipment have still to be called for and good relations between the United Kingdom and Ghana would obviously be of advantage to the United Kingdom engineering industry when the time came to tender.

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Europe, Africa and the Atom

A method of associating overseas territories with the proposed Common Market has been worked out by the Prime Ministers of France, Western Germany, Italy, Belgium and Luxembourg. After two days of delicate negotiations a basis for agreement has been found for both the Common Market and the Euratom projects. The drafting of the texts of the two treaties is now proceeding and it is expected that they will be signed in Rome during the second half of March. Prior to this, the text of the Common Market treaty will be submitted to O.E.E.C. for scrutiny in respect of its effect on the European free trade project. All is by no means settled; much of the progress to date was made possible by Dr. Adenauer's willingness to meet M. Mollet more than half-way. Both the proposed inclusion of African territories and the common ownership of fissile materials, except those processed for military use, raise difficult problems. National pride and traditional economic independence of the countries concerned will be formidable obstacles to ratification. As a Dutch spokesman put it "The integration agreement has been concluded—let's now try to bring about integration."

The decision to include Algeria as part of the Common Market from the start (with special exemptions from the rules in order to protect its nascent industries) and to open up progressively to the trade of all member countries the other foreign territories of the members are of the greatest importance to Britain's attitude to a free trade area. It would appear almost impossible for Britain to participate without the Commonwealth and Colonial territories if the Belgian Congo, all the French possessions in Africa, including Algeria, the French Islands in the Pacific and the Caribbean and Dutch New Guinea were included. A condition for the opening up of these territories to the exports of Germany and of other signatories of the treaty is that each should make contributions to the economic development of the territories. Included in the Prime Ministers' agreement is a paragraph to the effect that a convention, annexed to the treaty and valid for five years, should specify the scale of such investment. In return tariffs and quota restrictions are to be lowered progressively over a period of 15 years and simultaneously tariffs are to be raised on primary products entering the Common Market from other countries. This is tantamount to a new preference system which would cut right across Britain's Commonwealth trade.

There is little doubt that co-ordinated investment of this kind, side by side with the tariff-free entry of plant and equipment at competitive prices, would greatly accelerate the development of these territories. Likewise a co-ordinated nuclear energy programme could reduce the dependence of common market countries upon expensive imported fuel and would therefore lower manufacturing costs. The activities of the Messina Countries, and in particular the enthusiasm and diplomatic skill of M. Spaak, are slowly opening up for Europe a new era full of promise. Many political obstacles remain, but none that goodwill and basic community of interest cannot overcome.

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Air Transport in Central Africa

There has been a good deal of activity in recent weeks regarding the future of Central African Airways, the state-owned corporation operating mainly in the Federation of Rhodesia and Nyasaland which has been reported to be losing about £1,000 per day. In view of the long distances involved air transport is a vital factor in the development of the Federation, but the budget estimates for the current financial year contained no provision for prospective losses of this magnitude. It was expected that following the recent purchase of five new Viscounts, the financial results of the airline would show a substantial improvement. It is now suggested that experience has shown that Viscount aircraft cannot be economically operated from high level airfields.

Following a report that Hunting-Clan Air Holdings had notified the Federal Government that they were interested in acquiring a controlling interest in C.A.A. it has been announced that B.O.A.C. have also held discussions with C.A.A. Pan American Airways are also stated to be interested in acquiring control. Although there is at present no financial relationship, C.A.A. operate in partnership with B.O.A.C. on the Johannesburg-London route and one of the subjects under discussion has been the possible acquisition by C.A.A. of B.O.A.C. Argonauts and Constellations as Britannias and Comets become available. Hunting-Clan African Airways based at Salisbury run passenger, freight and mail services to Johannesburg and through Portuguese East Africa to Nairobi. They also maintain the Africargo All Freight Services from London to Nairobi and a coach-class passenger service. Pan American at present have no service to Rhodesia but operate from Lisbon down the west coast of Africa to Johannesburg.

One of the difficulties in negotiations between Hunting-Clan and C.A.A. is presumably the restrictions which apply to the private airlines in the operation of long-distance passenger services in competition with B.O.A.C. Hunting-Clan Air Transport for example recently purchased five new Viscount 53-seat airliners but have been prevented from using these on the East African route. It was announced that owing to these restrictions they have now arranged to sell two of these Viscounts. They have already leased the other three to the Lebanese Middle East Airline for use on their routes.

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Long Term View of Canada

A preliminary view has now been taken of Canada's prospects in the long term or at least as far forward as 1980. A Royal Commission on Canada's Economic Prospects has made a preliminary report which was published last month. The Commission estimate that the Canadian gross national product will rise from about 26 billion dol. in 1955 to 76 billion dol. (expressed in constant prices) by 1980. Not a great deal is said in the preliminary report on where the investment resources are going to be found to generate such a large expansion in the national income and indeed the rather surprising conclusion is reached that, by 1980, Canada may be a net exporter of capital. Assuming, however, that the finance can be found, the expansion in the national income is to come from an increase in the population from the present level of 15·6 million to 26·7 million by 1980. Output per man-hour is expected to increase from 2·5 per cent. to 3·2 per cent. per annum.

One of the consequences of this expansion in activity is expected to be a decline in the ratio of agricultural output in the national income from 13 to 6 per cent. Meanwhile, the output of what are called natural resource industries will go up from 10 per cent. to 15 per cent. and there is expected to be a slight increase in the ratio taken by manufacturing industry. Foreign trade is expected to go down in relative importance but the proportion of foreign trade with the United States will probably increase. In other words, the rapid expansion of Canada's national income and its accompanying prosperity for Canadians is not likely to decrease the dependence of the Canadian economy on the United States. That dependence might, of course, cover both investment and markets.

There are bound to be big opportunities for British industry, especially engineering industry, in a development of this size and pace. Engineering concerns in this country, perhaps electrical engineering concerns in particular, have shown that they are fully aware of the advantages which are available in the Canadian market. Looking no further than the figures those opportunities would seem bound to increase. Big developments lie ahead both in Eastern Canada and also in the Prairie provinces. The same is true of the West. A note on the intended opening up of a large tract in British Columbia appears on page 286. Success will not be measured, however, merely by adding up the number of contracts which the engineering industry among others may win in the Canadian market over the next few decades. The pace of

progress might be so quick, that despite the enterprising attitude of British concerns, they might find themselves elbowed out of the market to some extent by competition, especially from the United States. This danger would become very real if the expansion of Canadian industry were dependent to a very large and growing extent on capital from the United States. Various devices have been tried out in the last few years to increase the competitive power of British industry in the Canadian market. In particular, consortiums have been put together to pool knowledge and financial resources and these have met with some success. In the future, however, this may not be enough. A conscious and organised effort may have to be made to mobilise capital for Canada. If this country wants to be in on the *bonanza* in due course it must stake its claim now and the best approach would be an organised flow of investment funds from the United Kingdom to Canada.

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Changing Trade Pattern

The important thing about the returns for the United Kingdom's foreign trade is that exports rose last year by 10 per cent. to the record figure of £3,318 million. Imports, on the other hand, were only slightly above the 1955 level, at £3,889 million. Britain's overseas trade is with three main areas—the Sterling Area, Western Europe and North America. Exports to the Sterling Area increased slightly while imports fell. But to three important Commonwealth markets—Australia, Pakistan and New Zealand —exports fell. One bright patch is the increase in trade with the newly formed Federation of Rhodesia and Nyasaland. Over half the Federation's trade is with Britain, copper accounting for the bulk of the imports. It is to be hoped that the granting of independent status to the Gold Coast (Ghana) will also lead to an expansion of activity. Plans for a change of status for Nigeria and the British West Indies may also bring increased trade as these countries develop their resources. Trade with the Commonwealth as a whole, however, shows a relative decline.

Trade with North America, especially the United States, continues to increase. Indeed, in 1956 the United States was Britain's most important market. Trade with Western Europe also increased. The growth of trade between the European countries reflects not only the high level of industrial activity but also the progress towards a freer system of trade and payments through E.P.U. and the O.E.E.C. liberalisation policy. Perhaps the most heartening factor in the past year has been the success of the United Kingdom in making and exporting " new " products. In engineering the outstanding new lines are radio-communications and navigational aid equipment, Diesel locomotives, Diesel engines, commercial vehicles and tractors. Plastic materials have also sold well in the Western European markets. If this ability to change with the times can be maintained, Britain will have nothing to fear from participation in the moves for greater freedom of trade with Western Europe.

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Overcrowded Order Book

Disinflation or no, there are still many companies whose delivery delays are very long and in some cases getting worse. The situation is sometimes called " healthy," sometimes " gratifying " and only exceptionally do chairmen of companies find it cause for complaint. Yet there are few obstacles more serious to the expansion of Britain's export trade and few needs more urgent than the latter. Among companies reporting last week the size of order books was subject for frequent comment. None suggests that Britain's engineering industry is ailing. On the contrary; for most of them the chief problem remains how to keep abreast of increasing demand for their products. Particularly cheerful is the vigourous action advocated to reduce delivery delays by confident expansion and modernisation.

This is the case of J. and E. Hall, the manufacturers of refrigeration and vertical transport equipment, particularly for the shipbuilding and shipping industries. Their chairman, Lt. Col. Lord Dudley Gordon, said that every effort was being made to shorten the time required for delivery and completion, including a certain amount of " off-loading " to sub-contractors. The company, who are controlled by the Peninsular and Oriental Steam Navigation Company, export a large proportion of their output and are finding it necessary to quote both quick deliveries and keen prices to hold their own against " ever-increasing competition." J. Samuel White and Company have the same problem, now common to the whole British shipbuilding industry. Their chairman and managing director, Mr. J. A. Milne, reported that they have " a very full order book and will be fully employed for the next three or four years " in their shipbuilding and engineering department, though in others—particularly the high-quality boat building for which they are world-renowned—there is a shortage of work. The action now being taken by Cammell Laird, Austin-Pickersgill, Swan Hunter and others (see Weekly Survey, British Shipyards Go Forward, February 15) suggests that the British shipbuilding industry is at the beginning of an expansion era unparalleled this century.

Two other companies, H. M. Hobson Limited and the English Electric Company Limited indicate that large-scale expansion is being undertaken to meet a fast-rising demand for their products. H. M. Hobson and their subsidiary company, Integral Limited, report an extremely healthy order book " spread so that we are able to look to the future with confidence." Their chairman, Mr. T. Simpson, highlights the progress made on the atomic energy side of their business, into which the company have invested large resources and where they have applied the skills acquired in the manufacture of hydraulic and other components for aircraft. They have worked " at full pressure during the past year " on orders for electro-mechanical control systems for reactors and isotope handling mechanisms. English Electric report that they are rapidly overhauling their rivals in size of turnover, profits and size of order book. The easier delivery conditions which are reported suggest that they have made considerable progress in overcoming the problem of the crowded order book for there is no sign of any slash in the demand for their products.

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Expanding Coal Output ?

For the first seven weeks of 1957 there has been a substantial improvement in the performance of the coal industry, output showing an increase of nearly 1 million tons compared with the corresponding period of 1956. Early in January, the chairman of the National Coal Board forecast that the output of deep-mined coal for the whole of 1957 would rise by a little over 1 million tons, while opencast output could be raised substantially from the 1956 total of 12 million tons, provided site clearance certificates could be accelerated. On the first few weeks' showing there would appear to be every prospect that this estimate will be exceeded.

The improved output this year has been due to two main factors: an improvement in the overall manpower position and a reduction in absenteeism, particularly in involuntary absenteeism which mainly reflects the sickness level in the industry. In so far as the latter is due to the relatively mild winter it must be regarded as a factor which may not continue for the remainder of the year. The coal industry has, however, been one of the main beneficiaries from the recession in the motor vehicle and domestic appliance industries and the overall labour shortage was approximately halved in 1956, the manpower shortage at the end of the year having been reduced to 9,000, mostly in the Yorkshire coalfield. Probably a third of this could be made good by the employment of Hungarians, if the miners' agreement is secured, apart from further transfers of men from other industries. On the other hand, the proposed removal of penalties for absenteeism in return for agreement to the employment of Hungarians is expected to lead to further loss of production from this cause.

The reduction in manpower should enable the Board to derive full benefit from the increased mechanisation and reconstruction schemes already undertaken and those still to be completed. In 1957 18 major colliery reconstruction schemes are expected to be completed, more than in any previous year. Thus while there are conflicting influences at work there would appear to be good prospects that the current year will see an end of the virtual stagnation in output which has prevailed for the last few years.

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More Oil for All

There was good news last week for users of petroleum products. The Texas Railroad Commission yielded to strong political pressure from Washington—backed by a personal appeal by President Eisenhower—and agreed to raise the level of " allowables " for March by more than 200,000 barrels a day, an increase of six per cent. Shipments to Europe are expected to increase by the equivalent amount, from the January average of 450,000 barrels a day to 650,000, though the necessary diversion of tankers from the Cape route to the United States Gulf will make the nett addition to European supplies about half this. Nevertheless the fear that Gulf shipments would decrease has now been dispelled. The inclusion of Britain among the beneficiaries for the March allocations of the O.E.E.C. Oil Committee—for the first time—will produce a useful contribution to the total amount available here.

Lord Mills, the Minister of Power, announced that the oil supply position had improved sufficiently to warrant a review of the restrictions on consumption. For March and April the cut in deliveries of Diesel oil will be reduced from 20 to 10 per cent. The Government consider it " prudent " to proceed on the assumption that a further rationing period for private and commercial transport will be necessary but there is every prospect of an increase. Deliveries of fuel oil to industry will be maintained at the present level of 90 per cent. of normal. Trawler owners and farmers will be able to buy their full requirements of Diesel oil from April 1.

These developments are, as the Federation of British Industries stated, " very gratifying." Some of the seasonal increase in demand for petrol will be met. Diesel-powered vehicles and equipment will be adequately supplied; in the case of trawlers and agricultural tractors spring activities will not be hampered by a shortage of fuel. Yet the need to build up stocks for the winter—when demand is highest—must not be forgotten. No-one can be sure that Middle East supplies will flow freely this year. Political problems appear to be no nearer solution than before the Suez Canal was blocked. The improvement in supplies from Texeas is therefore of the greatest importance.

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Supertankers and the Clyde

In order to allow the Clyde shipbuilding industry to compete effectively for the new super-tankers, a project is announced to be at the advanced stage of negotiation for a new fitting-out basin.

The scheme, if it materialises, will cost about £750,000. The new dock will be on the lower reaches of the river so that it will provide facilities from up-river stocks. The Clyde has a long association with the Admiralty in building naval tonnage and has built the world's two largest passenger ships. Nevertheless, the facilities for fitting-out really large vessels have been limited to a few well-sited yards down-river from Glasgow. The effect of the new project would be to provide bigger fitting-out facilities for yards which so far have not competed in the super-tanker class.

The Scottish Council (Development and Industry) has also announced that a new graving dock is under consideration. Clydeside has been trying to obtain such a dock, which would probably cost about £7 million and would take the biggest ships in the world, ever since the war. It would be a major achievement for the Scottish shipbuilding industry if both these projects could be realised in the near future.

Clydeside's claims to be the cradle of the world steel shipbuilding industry are considerable if not entirely unchallenged. Of recent years the Clyde's reputation as a port has had its detractors and it was something of a shock to find that a foreign company was running the Clyde's sparse North Atlantic route instead of Canadian Pacific Railways some time ago. When the ports and harbours were nationalised, the Clyde showed its mettle by resisting control from London—and resisting successfully. These two new shipbuilding projects suggest that a spirit of enterprise is asserting itself again. It is fitting that the river which produced the "Comet" and her less famous but technically more significant contemporary the "Elizabeth" should be at the forefront of the drive to build the world's fleet of super-tankers.

Letters to the Editor

WE NEED THE MOTORWAYS

SIR, Road construction under way in this country consists merely of improvements to the present system, so that the motorways referred to in the Special Roads Act of 1949 are still as far away as ever. The existence of frequent crossings and an increasing traffic density emphasise the difficulties of applying minimum high-speed regulations.

A bold policy is needed, for the construction of new motorways which will be comparable with the current practice abroad. French, Italian and German road construction planning appears to bulldoze its way through politics to handsome mileages, while our own meagre programme does not so much as permit modern high-speed construction equipment to be used. The difficulties of the situation are undoubtedly moderated by the very substantial mileage of good secondary (though difficult) roads that there are in this country. The construction of highways in the United States at the present time amounts to 41,000 miles, with the emphasis being placed on their high-speed usage. No obstacles are recognised, even in the cities, and in one instance the highway goes right through a building.

In discussing the road speed of heavy vehicles the authors of the article "Commercial Vehicles and the New Motorways," published on page 206 of your issue of February 15 last, suggest that, for an average speed of 40 m.p.h., nearly every existing British-made commercial vehicle of 2 tons and over would be precluded from being used. Whilst not agreeing with this statement, it is very necessary to mention economy as the main requirement at present governing design and there is unlikely to be any easing of this condition. Designers have already pared off all excess weight and there is very little more that can economically be done in this respect.

Engine power can only be improved by increasing the sizes of the clutch or fluid coupling, the gearbox and the axle. Higher speeds mean bigger brakes and larger servo units. On heavier vehicles, power assistance is commonplace for brakes and is becoming increasingly used for steering. Semi-automatic and fully automatic operation of certain types of gearbox are in an advanced state of development in this country and, fortunately, will not adversely affect economy. Long-distance high-speed journeys call for a very substantial degree of comfort in the driving cab and this aspect has received much attention in the case of all classes of goods vehicles.

It is certain that some of the present strict examination requirements relating to passenger vehicles would be extended to vehicles suitable for the new motorways. This, in turn, would require many additional certifying officers.

The foregoing considerations indicate a heavy increase in vehicle costs, and manufacturers will need assurances from the major transport undertakings that substantial orders will be forthcoming. It takes from four to five years from the commencement of a new design for it to attain production. There appears to be little fear of the roads being available before the vehicles.

Yours faithfully,
L. HARTSILVER,
Chief Designer—Heavy Engineering.
The Daimler Company, Limited.
February 21, 1957.

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SPONSORED RESEARCH

SIR, The leading article, "Laboratory in Scotland," in your issue of February 15, commences with "A word out of context does not have a clear cut meaning," and ends with "Sponsored research organisations, on the other hand, have everything to gain and nothing to give." After reading the whole of the article, the meaning of the last sentence is not entirely clear to me. Apparently, if an organisation is set up in this country by an American commercial research organisation that makes a very substantial profit out of research work, it is in some way superior and more altruistic than, for example, a British-sponsored research organisation that ploughs back all its profits to extend its facilities.

This appears to be based on the acceptance of a false distinction between the terms "fundamental" and "sponsored," which assumes that all research work that is published freely is "fundamental" and that all that is secret is "sponsored." My own definition of sponsored research is research which is wholly paid for by a sponsor and carried out in laboratories other than those belonging to the sponsor. The sponsor is the individual, group of individuals, or organisation paying for the work. Obviously, the sponsor may wish to obtain exclusive benefit from the work, either as patent rights, or, in some cases, as confidential information, but secrecy is not by any means normal in sponsored research. Well over 90 per cent. of the work carried out by the Fulmer Research Institute is published. In the ten years of our existence, about 100 papers have been published describing work carried out in the Institute's laboratories. Some 59 patents have been taken out and, in most cases, have been assigned to the sponsor. It is not clear from your article what is to happen to patents arising from inventions made at the Arthur D. Little Research Institute. Can it be that no inventions will be made or patented, or do they belong to Arthur D. Little Inc.?

Turning now to the question of "fundamental" research, the definition of this term is controversial and difficult, although most people have a fairly clear idea what it means. Personally, I regard the establishment of new knowledge and data as fundamental, and distinct from the application of existing knowledge, which I describe as applied research. Either can be sponsored. Whatever definition you accept, however, it is difficult to see how work on a new type of polythene can be claimed as fundamental when investigations on the mechanism of precipitation hardening in alloys, the establishment of thermodynamic data of metallic compounds, or the preparation of superpure silicon, which are typical of the problems currently under investigation at Fulmer Research Institute, are placed in a lower category because they are "sponsored."

While one must applaud and rejoice in the enlightened self-interest that results in United States sponsorship of research in this country, one may perhaps question the implication contained in the last sentence of your leading article of superior altruism in this particular case.

Yours faithfully,
E. A. G. LIDDIARD,
Director of Research.
Fulmer Research Institute,
Stoke Poges.
February 22, 1957.

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CATHODIC PROTECTION OF BALLAST TANKS

SIR, May we refer to the note, under the above heading, published on page 202, February 15?

In this article, you described the new development, of which we sent you particulars, of using an impressed current system for the cathodic protection of the ballast tanks of an ore carrier and stated that such a system offers advantages over the more conventional magnesium-anode type of installation.

We omitted to make it clear, however, in the notes we sent to you, that this development is not applicable to oil tankers (except for polarisation when gas-free in dry dock) because of the fire risk. Consequently, magnesium or some other sacrificial anode will continue to be employed, probably to a greatly increasing extent, for the cathodic protection of ballast tanks of such vessels.

Yours faithfully,
A. C. VIVIAN.
Metal and Pipeline Endurance Limited.
February 21, 1957.

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COUPLING TUBES

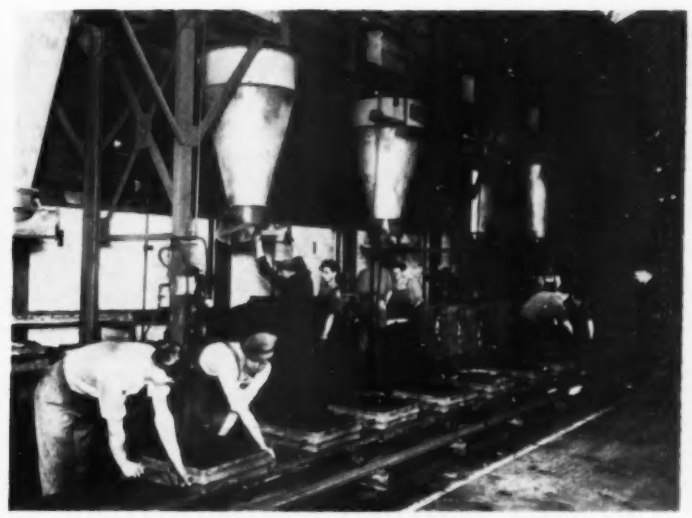
SIR, Mr. J. J. Granville's letter in your issue of February 22 raises a point of importance concerning the function of the inner sleeve in our high-pressure pipe coupling.

Frankly, we admit that in some instances the omission of the inner sleeve during assembly might endanger the subsequent reliability of the coupling under load. Indeed, in the application of the coupling to polythene tubes, which is in any case a low-pressure condition, it is unqualifiedly indispensible to have the inner sleeve in place, since on this element depends the possibility of anchoring the tube against axial forces which are resisted by the re-action of the outer sleeve through the wall of the polythene pipe and on to the outer surface of the inner sleeve, thereby producing a pinching action which ensures that the more the pipe is pulled the tighter the ring assembly becomes. Clearly, no polythene tube coupling could be established at all unless the inner sleeve were forced into place as a preliminary operation.

Regarding Mr. Granville's point we can only say that all mechanical devices depend for their good performance in service on correct assembly and adjustment when being prepared for use, and our coupling is no exception to this rule. By slightly complicating the design it would be possible to anchor the inner sleeve in situ somewhat more positively than by the present means (friction) but even then no guarantee could be given against the occurrence of failure if carelessness defeated the objectives of the design.

Your faithfully,
p.p. Allied Art Industries, Ltd.,
R. J. MITCHELL,
Director.
February 25, 1957.

Moulding in the dry sand section of Beans' No. 1 foundry is by means of two sand rammers, each with a turntable and four pattern strippers.



No. 2 foundry is devoted to the mechanised production of light castings in green sand.

COMPONENTS AND ASSEMBLIES TO ORDER

JOBBING WORK ON THE GRAND SCALE

Beans Industries, Limited, Hurst-lane, Tipton, Staffordshire, are an old-established company whose origin can be traced back to a manufacturer of hearth furniture operating in Dudley in the 1820's. The company entered the automobile industry at an early date, and have developed a large business in the manufacture of castings, components and sub-assemblies. The site of the present offices and works was acquired about 40 years ago, and the business is now concentrated at Tipton.

About two years ago it was decided to modernise the works and to increase the manufacturing capacity, both for automobile components and for the engineering industry generally. This modernisation, which is now virtually complete, has involved the complete reconstruction of two grey-iron foundries and the building of a new engineering works on a site near the existing shops. In both the foundries and the engineering section of the works the layout is designed for large-scale production, but the need for flexibility has also been taken into account.

CASTINGS FOR THE TRADE

Of the two foundries No. 1 is the larger. It has two sections, one for green sand moulding and the other for dry sand, and is equipped for the production of internal combustion engine cylinder blocks and heads, gear boxes and similar high duty grey-iron castings in a range of sizes from about 14 lb. to 5½ cwt. The foundry has its own core-making equipment and sand preparation plant.

Core sand is received by road, as are all the other materials used in the works. The sand is dried in two rotary driers, fired by Mond gas, which is taken from the mains of the nearby Mond gas works, the only commercial supplier of producer gas in the country. The sand driers, like the rotary coolers which are in line with them, each have a capacity of 5 tons an hour. The coolers are equipped with a wet-dust extraction plant. Cool, dry sand is lifted by bucket elevator to two 30 ton storage hoppers, from which it is fed by gravity to two sand mixers each of 10 cwt. batch capacity. An elevated platform enables prepared sand to be taken by hand barrow to chutes serving the core-blowing machines and hand core making benches.

Core-making equipment is arranged in two groups, comprising, in effect, two separate core shops served by the same sand-mixing plant. In the first line there are six semi-automatic core blowers and strippers, with one horizontal core blower, one cartridge blower and six circular tables for hand core making. The core-making line is served by a pendulum conveyor leading to three vertical, 3-pass, 50-tray, coke-fired core drying stoves. Baked cores are taken away from the unloading side of the core ovens by the same conveyor, and pass to a trimming, inspection and gauging, and blacking area. After the blacking has been dried, for which purpose there are three single-pass vertical driers, the cores pass to storage racks adjacent to the appropriate core setting areas.

In the second core section, which runs at right angles to the first, there are six hand-operated core blowers, with a pendulum conveyor for taking green cores to a set of three drying stoves, identical with those in the first core making section. Baking, trimming, inspection and gauging arrangements are similar to those of the other section, and finished cores pass, by means of a third pendulum conveyor, to the core storage area. A reserve core sand preparation plant is located at the end of the second core-making section.

SAND MOULDING

In the green sand section of the foundry the moulding machines are arranged in a line with the plate conveyor for moulds running between the machines and the core storage racks. Drag halves of moulds are produced by means of a sand rammer, a jolt-squeeze turnover machine and a plain jolt-squeeze. A duplicate set of these machines produces the cope halves of the moulds. Coring and closing of the moulds is carried out on the conveyor, which takes them round to a pouring station. From this point they continue on the same conveyor behind the cupolas to a transfer point at which they are lifted by power hoist to a second plate conveyor leading to the shake-outs.

Pouring is from ladles suspended from a monorail, the metal being melted in four 4 ton per hour cupolas, each pair of cupolas being equipped with a penthouse-type spark and dust catcher. Each cupola has its own skip charger, the charge being made up by hand from two sets of radial bins, one to each pair of cupolas. A dial platform weighing machine is provided for each set of bins. A stockyard, with two 5 ton overhead electric travelling magnet cranes runs at the back of the line of cupolas, and the radial bins are kept charged by these cranes. The same stockyard and cranes serve the cupolas in the dry sand section of the foundry.

The dry sand section of the foundry abuts on that devoted to green sand work; physically, the one is a continuation of the other. Moulding is by two sand rammers, with two 16 ft. diameter turntables, each carrying four pattern strippers. Moulds pass by roller conveyor to an adjacent bay where they are lifted by overhead crane to the bogies of six coke-fired mould stoves. Here they are dried on a 7 hour cycle at 400/450 deg. F. overnight.

Dried moulds are lifted by crane to one of seven roller conveyors leading away from the drying bay. These conveyors are used for mould storage, assembly and pouring, four of them being normally in use for assembly and pouring, while the other three are for storage purposes. Overhead cranes enable the conveyor lines to be used flexibly.

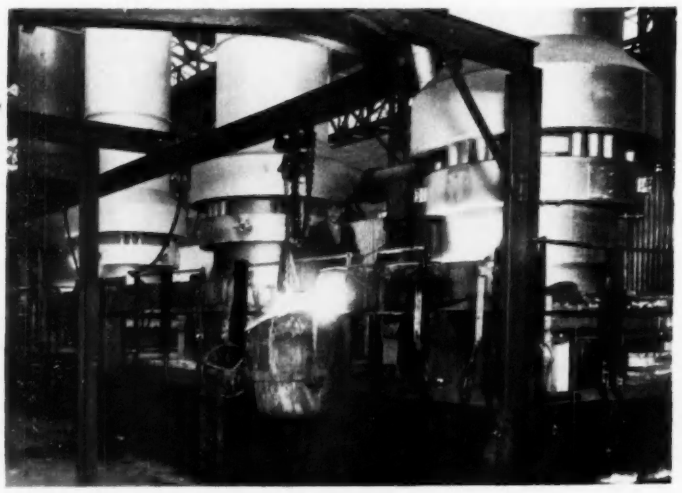
The four pouring conveyors lead straight to a set of four cupolas, of similar design to those previously mentioned, and served by the same stockyard and cranes. Two of these cupolas are, however, arranged as 3 ton per hour units, the other two being capable of melting 4 tons per hour. Pouring is from ladles suspended from a monorail. Cast moulds are lifted by power hoist to the conveyor leading to the shake-outs.

CLEANING AND DRESSING

The green sand and dry sand moulds having now come together on the same mould conveyor, they pass to two vibratory shake-outs. From this point the green sand moulding boxes are returned by the mould conveyor to a point near the cupolas, and from here they are transferred by belt and roller conveyor to the moulding machines. Boxes for dry sand moulding make a short journey by roller conveyor to the two moulding turntables.

Wet-washer type dust and fume extraction plant is provided for the shake-outs. Castings are lifted from the shake-outs by power hoist to a pendulum-type casting cooling conveyor, approximately 3,960 ft. long, with a cooling cycle of about six hours. The cooling conveyor runs in three levels, and on the top level there is a core shake-out section. Here the castings are lifted from the conveyor by power hoist to one of two vibratory shake-outs, and then returned to the same conveyor which takes them to two Wheelabrators of the four-wheel type, and thence to dressing and fettling by swing grinders and chipping hammers. All cored castings go next to a water test, and then finally to inspection benches where they are jig checked. A dispatch bay adjoins this point.

Moulding sand preparation is carried out in a single plant serving both sections of the foundry. Used sand from the shake-outs and



Melting equipment is similar in the different sections of the two foundries. The cupolas are in line, with a monorail for pouring.

spillage sand from the moulding sections are returned to the sand plant by underground belt conveyors. New sand is brought in by road vehicle to two storage hoppers. Two 30 ton per hour continuous sand mills with two 60 ton storage hoppers, a disintegrator, a rotary screen, and magnetic separators in two stages are the principal items in the plant. Prepared sand is distributed for moulding by overhead conveyors feeding the moulding machine hoppers.

LIGHT MECHANISED MOULDING

No. 2 foundry is equipped for the mechanised production of castings in green sand from about 6 to 140 lb. Such items as brake drums, flywheels and manifolds are in regular production, but the foundry is not confined to automobile work. Like No. 1 foundry, it makes general engineering castings of any type within its capacity.

The foundry is centred on a plate-type mould conveyor, running in front of eight jolt-squeeze moulding machines, which work in pairs to produce copes and drags. The two parts of the mould are closed on the conveyor, coring being carried out at this point if required. The foundry has its own core shop equipped with sand preparation plant, horizontal core blowers, hand core-making benches and a pendulum conveyor. There are two single-pass coke-fired core stoves, from which the cores pass to trimming, inspection and blacking.

The melting plant, to which the moulds are brought by the conveyor, comprises four 3 ton per hour cupolas, of similar design to those in No. 1 foundry, but hand-charged from bunkers at charging door level. A separate stockyard is provided for these cupolas, with an overhead magnet crane to lift materials to the high-level bunkers. Pouring is from hand ladles suspended from a monorail.

There are two vibratory shake-outs from which the castings are taken by a basket-type cooling conveyor. After cooling, the castings are passed through a Wheelabrator, dressed, fettled, inspected and dispatched.

A description of the general engineering shops at Beans will be described in a subsequent article.

MACHINING BY SPARK

LATEST THEORY AND PRACTICE

The principles and applications of spark machining were dealt with in a paper by Mr. D. W. Rudorff, director of Sparcatron Ltd., Research Department, London, which was read before a meeting of the Institution of Mechanical Engineers on February 22. In this process, he wrote, spark discharges were produced in rapid succession between a cutting electrode and a workpiece electrode when the potential difference between them was raised to such a value that electric breakdown took place in the medium filling the interspace and it became conducting. In practice, the interspace was filled with a liquid dielectric, such as hydro-carbon oil, and the gap between the electrodes was adjusted so that discharge from a condenser in the circuit took place when its voltage reached 0·73 times the direct-current supply, tests having shown that this was an optimum value.

After the condenser had discharged and the dielectric had become de-ionised, re-charging took place and the next discharge followed. The spark repetition rate with different condenser capacities would vary with the operating conditions but, with a gap breakdown voltage of 150 volts, might be expected to lie between 10,000 sparks per second with a capacity of 0·25 microfarads and 380 sparks per second with a capacity of 256 microfarads. For a given supply voltage and condenser capacity it could not be increased beyond a point determined by the speed at which the gap was de-ionised and cleared of debris. Forced circulation of the dielectric fluid through the gap was therefore an advantage with high spark erosion rates.

A liquid hydrocarbon, such as transformer or paraffin oil, was generally employed as a dielectric. The essential requirements were high dielectric strength, rapid quenching of the spark after discharge had taken place and as speedy a break-down as possible under given voltage and spark gap conditions once the voltage had been applied. In addition, the fluid must provide effective cooling, be capable of carrying away swarf particles and have a high degree of fluidity. Results attained with a given liquid would, however, also vary with the workpiece and electrode material as well as with the method by which the spark discharges were produced. Tests had shown that for general use a mixture of light naphthenic machine oil and paraffin oil resulted in a rate of material removal 25 to 30 per cent. in excess of that obtained with paraffin oil alone. An important point was that certain oils and oil mixtures resulted not only in higher cutting speeds than with paraffin oil, but that surface conditions were also improved.

AUTOMATIC HEADS

A typical spark-machining installation described by the author consisted of four working heads which were supplied with direct-current from the three-phase mains through a 6·5 kW selenium rectifier. In each head a bath for the immersion of the workpiece electrode in the dielectric fluid was mounted on a table to provide lateral movement relative to the tool electrode. The latter was attached to a servo-controlled ram which was positioned between two sets of balls. The operation of each head was automatic until its circuit was broken and the system circulating its dielectric fluid was cut off by a limit switch. This switch could also be adjusted to give a predetermined travel of the tool electrode.

Feed control mechanism was provided to maintain the gap between the electrode and the workpiece at the distance at which spark-over would occur at the pre-determined voltage. Since during operation both the workpiece and the tool electrode were eroded, this control must maintain the movement of the latter towards the former at such a speed that the sparking voltage remained at its prescribed value. Any tendency to hunt must be prevented, rapid response (which meant a driving mechanism with low inertia) was essential and speedy reversal of the feed motion was necessary to eliminate overshooting and consequent short-circuit between the electrodes.

In all practical electrode feed mechanisms the control drive was actuated by an error-indication signal obtained from an electrical sensing device which was responsive either to the gap voltage or to the working current or both. The servo-mechanism effecting the movement of the electrode might be of the motor-driven, solenoid-operated or hydraulic pattern. In a typical example of the former, the electrode was driven through gearing by a reversible direct-current motor so that it could be lowered to establish and maintain the correct gap width. It could also be raised should the gap become bridged by an accumulation of swarf or be short-circuited by the control overshooting.

RATE OF MATERIAL REMOVAL

In spark machining the rate of material removal for a given set of electrical parameters depended upon the composition and physical properties, dimensions and shape of the workpiece and electrode, as well as on the nature of the dielectric fluid. No definite relationship between those factors and the rate had, however, yet been established. Another difficulty was that the cutting rate, expressed in units of weight or volume of material removed per unit time, was bound up with the surface finish produced, and this varied with different materials and with the nature of the dielectric fluid. In the majority of cases encountered in practice it was not therefore possible to estimate spark-machining times with the accuracy customary in conventional methods.

The electrical parameters of the circuit exerted an overriding influence upon the rate at which material was removed from the workpiece. The most effective means of controlling this rate was to vary the condenser capacity. With increasing capacity this rate also increased until a point was reached when the amount of swarf dispersed in the dielectric liquid could not be removed rapidly enough from the spark gap to prevent arcing. Flushing of the gap by forcing a stream of dielectric liquid through it at high velocity was therefore essential when a high cutting speed was aimed at. When trepanning operations with hollow electrodes were carried out, circulation through the electrodes was highly beneficial.

The loss in weight of both the cutting electrode and workpiece depended to a considerable extent on the nature of the material. A great many different materials had been investigated to find one for the cutting electrode which combined the highest cutting rate with lowest weight loss per unit weight of workpiece material removed. Other requisites were low cost, ready availability and ease of machining to shape by conventional processes.

Up to the present time various brasses (especially B.S.249) and copper had been found to be most generally suitable. Higher cutting ratios could be attained with silver, graphite or carbon. From the points of view of electrode wear resistance and mechanical machinability copper-graphite, however, appeared preferable, although its cutting rate was slightly lower than any of the others. Tungsten-copper was an excellent electrode material, both as regards cutting speed and low wastage, but owing to its cost its use was restricted to applications where minimum electrode wastage was essential.

MACHINING TOUGH MATERIALS

The spark-erosion process made possible the machining of metals which, because of their

hardness or toughness, could not normally be dealt with by conventional tools. It could also be used to produce irregular or intricate shapes, openings and cavities, which were difficult or impossible to form by the usual methods. Here the relatively slow rate of metal removal was of secondary importance.

Cutting-off was a most useful application, especially where a very narrow cut was required. In its simplest form the tool was a strip of sheet brass, which was attached to the electrode carriers of the machine and was fed downwards by a servo-mechanism to the workpiece. In face forming, the most frequent application of which was the production of tungsten-carbide screws, thread cutting dies and chasers, the cut was also made vertically, the edge of the workpiece being shaped in accordance with the profile of the electrode as it descended.

The spark-erosion process was greatly superior to conventional drilling, excising, profile forming and slotting operations, owing to the fact that a rotary movement of the tool was not essential, so that holes of practically any configuration could be produced. The electrodes should be hollow to reduce the effective area to be cut and to facilitate the removal of swarf. Where holes of small diameter had to be produced a wire electrode was used which, owing to its relatively large wastage, was fed from a reel through a straightening and guiding device.

IRREGULAR APERTURES

An important use of the spark cutting process was the formation of irregularly shaped apertures in tungsten-carbide extrusion and blanking dies. The most irregularly shaped apertures could be produced in this way in one-piece die blocks. In the case of forging dies, restoration of the die cavity by spark machining in the hardened condition was now widely used. This operation was usually performed with brass or copper electrodes made by hot stamping them from a master die. In order to allow for the clearance required for the spark gap between the electrode and the die face, the stampings were immersed in an etching solution to reduce the overall dimensions to the required degree. It was also possible to perform the entire die-sinking operation by spark machining from a hardened blank die block, but where large cavities had to be produced the die cavity should be first roughed out from the soft material, finishing being effected by spark machining the hardened block.

Cylindrical grinding machines could be adapted for spark grinding by replacing the grinding wheel by a circular electrode and adding the necessary control apparatus. The electrode wheel was automatically fed forward to the work until sparking took place across the gap filled with dielectric liquid, which was directed over the work and wheel. Finishes from about 250 to 8 micro-inches could be obtained by adjusting the electrical circuit. This method had been found ideal for the preparation of test pieces of very small diameter.

SPARK PRODUCED SURFACE

The effect of spark erosion on the work surface was to cover it with small craters, the shape and size of which were determined by the electrical discharge parameters, by the nature of the electrode material and by the dielectric fluid. The surface had a matt appearance, the marks typical of conventional machining being entirely absent. Large variations in crater formation occurred owing to some of the vaporised material being thrown on to their sides.

The cutting characteristics were considerably influenced by the spark gap, which should be theoretically adjusted to give a breakdown voltage of 73 per cent. of the supply voltage in order to satisfy the conditions for maximum energy transfer. It had been demonstrated, however, that the maximum stock removal rate occurred both under this condition and at a much lower breakdown voltage when accompanied by a higher average charging current. This was due to intermittent arcing which led to a frozen pool of metal on the surface with an underlying layer of considerably higher hardness than the parent metal. It was therefore advisable to operate the machine with the gap setting based on the higher breakdown voltage and to accept the somewhat rougher finish which resulted, rather than to obtain a finer surface finish but having a damaged sub-surface layer underneath.

GRANDSTANDS OF MANY USES

Great occasions call for celebrations, and celebrations usually include processions, whether they be held in America, Europe or Africa. The granting of independence to the African state of Ghana is certainly an occasion for great celebration, and to enable the proceedings to be seen by many folk, grandstands have been erected, together with crush barriers, along the route of the procession.

Grandstands are expensive items to build, and for such occasions as this, their span of life is limited. Consequently, any scheme that can make subsequent use of their components has many points to commend it. The grandstands at Accra have been built from slotted angle supplied by Dexion Limited, 65 Maygrove-road, London, N.W.6, and have been designed to seat some 10,000 people. In addition, there is an entrance arch at the airport and a pylon to carry the national flag. Four and a half miles of crush barriers have also been erected to guard the main route of the procession. It is claimed that these grandstands are the largest slotted-angle structures in the world; in all, more than half a million feet of Dexion have been used.

After the celebrations have been concluded, the stands will be dismantled, and the angle used to construct the frames of houses and schools, two items which are among the greatest needs of the new state. The largest of the three grandstands measures 348 ft. in length, and has 15 tiers of seats rising to a height of 23 ft. Its capacity is 7,500 people. The construction was carried out by 140 unskilled Africans, who had never seen this type of work before. Half of them were concerned with transporting the materials to the site, and the other half were equally divided into two construction teams, one concerned with the pre-fabrication of the frames and the other with their erection. The frames were constructed from an original prototype made by the European supervisors, which acted as a jig for the later ones. After two hours' instruction, average assembly time was 12 minutes per frame, and in all 868 frames were made on the site. All parts were cut to length before they were sent out to Africa, so that only assembly was required at Accra. The canopies above the stands are slung below light alloy girders, and are themselves of light alloy. The total time for erection from first entering on the site was six and a half weeks. The structure of the main stand was tested after erection by a detachment of 400 troops from the Gold Coast Regiment, who carried out squad drill on the stand. They are shown in Fig. 2.

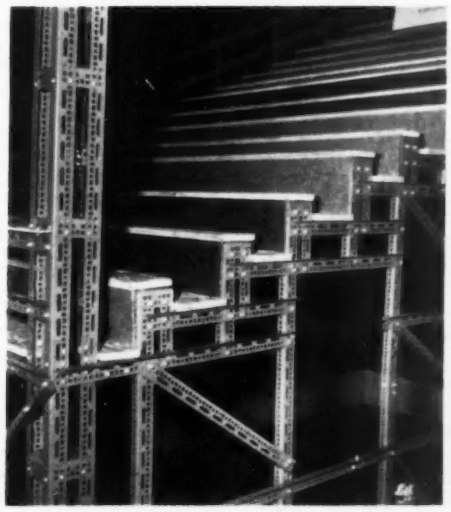


Fig. 1 (above) A model shows the detail construction of the frames.

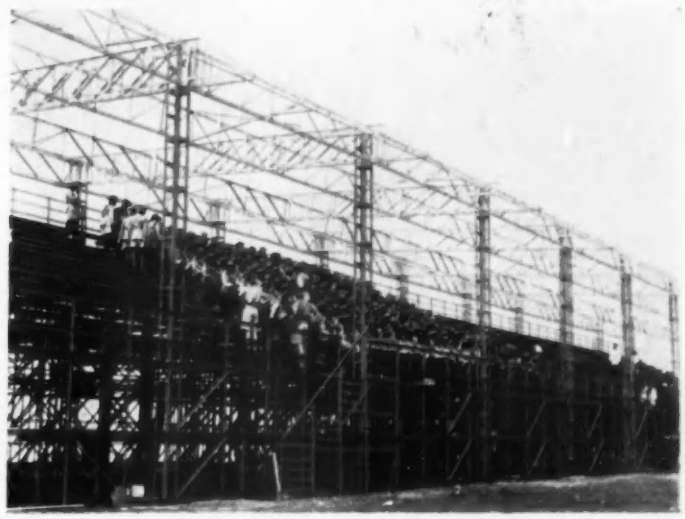


Fig. 2 (right) The grandstands for the celebrations of independence at Accra are made from slotted angle. Subsequently the angle will be used for the frames of houses and schools.

* * *

MIXED-FUEL DIESEL ENGINES

An attempt has been made to ease the fuel problem of unbalanced demand for different grades (see Weekly Survey, page 135, issue of February 1) by running Diesel engines on a mixture of gas-oil and petrol. F. Perkins, Limited, of Peterborough, have carried out extensive tests on their engines, and report that they will all operate satisfactorily on mixtures containing up to 50 per cent. by volume of petrol. Higher proportions can be used, but these involve modifications to the injection equipment. No modifications are required up to 50 per cent. by volume of petrol, although the maximum fuel-rack setting must be increased to compensate for the lower volumetric calorific value of the fuel, in order to restore the power output of the engine. Adequate lubrication of the injection equipment is obtained from the gas-oil component of the mixture, but care should be taken to ensure that there is no restriction on the suction side of the fuel lift pump, which might lead to vapour-lock difficulties. Intermediate fuels such as kerosine can also be used.

Typical tools for steel pen manufacture. Left, four-stage follow-on tools for blanking. Centre, raising tools. Right, rounding tools. Samples of the pen produced with these tools are shown in the centre of the illustration.

PENS AND PRESSINGS

AN OLD TRADE WITH MODERN APPLICATIONS

The steel pen, or pen nib, ranks with a small number of other metal articles such as buttons and buckles, as an early example of large-scale production. When and by whom the steel pen was invented is not known, but it was almost certainly developed somewhere in the Birmingham district, possibly as early as the beginning of the Eighteenth Century. The early pens were crude and expensive, and it was not until the art of the tool maker was brought to bear on them that they became both cheap and of good and consistent quality.

A pioneer in the production of high-quality steel pens in large numbers was Joseph Gillott, who started a small factory in Birmingham in the early 1820's, and very quickly, by the application of proper tooling, built up a most successful business, producing pens in quantities which, at the time, were remarkable. By the 1830's Gillott was making about 36,000,000 pens a year, and before the decade was out he had found it necessary to move his business twice, the second time to large premises built expressly for pen-making. Joseph Gillott's successors in business carried on in the Birmingham factory until 1955, when the firm, still controlled by the same family, and now known as Joseph Gillott and Sons, Limited, moved to newly-built premises at Dudley, Worcestershire. The reasons for the move were two-fold. In the first place the Birmingham factory was not suitable for the extensive modernisation which the firm had decided to carry out, and secondly, the labour position in Birmingham at that time was difficult. Labour conditions were a little easier in the Dudley district, and in fact many of the firm's employees travelled from that area to Birmingham daily.

The new factory is a single-storey building designed on " open " lines, there being a minimum of walling or partitioning between departments. Factory and offices are heated throughout by electric resistance heaters built into the floors and thermostatically controlled. Large quantities of pens, for writing, drawing and mapping, are still produced, but added to this production there is now a great variety of small precision pressings in various metals for the electrical and mechanical engineering trades, and for many other users.

THE ESSENTIALS OF A PEN

Essentially, a pen must write; so much is obvious. But matters are not quite as simple as that. Only a combination of qualities will enable a pen to do what a user demands of it, probably quite subconsciously, for the pen is such a common object to most people that it never gets a thought unless it fails to do what is expected of it. To meet the user's needs the pen maker has to ensure that the pen shall have a perfectly-shaped point, be smooth and sufficiently flexible, but not too " soft," and be consistent in all respects. Users develop a preference for a size and type of pen, and expect every one to have the same " feel." The pen maker has to see that they do.

In the past the making of a pen could be divided roughly into 16 operations. The sheet steel as received from the steel makers was first bright annealed and rolled to the required gauge, and then followed blanking, side slitting, piercing, and marking (all done in hand presses), annealing, raising (again in a hand press), hardening, tempering, cleaning, grinding across and lengthwise, slitting (once more in a hand press), colouring, and varnishing. These are still the basic operations which have to be performed on a pen, though the processes are different to-day, and they are still undergoing development.

As might be expected, some of the operations, which used to be on the basis of one operation one machine, are now combined, and some, as far as the pen maker is concerned, are no longer necessary. Pen steel, which is a 1 per cent. carbon steel, can now be obtained from the steel makers in coil form, bright and hard rolled, and it is no longer necessary for the pen maker to do any cold rolling. The pen steel is now stocked in coils in a range of thicknesses from 0·002 in. to 0·014 in., together with stainless steel strip and numerous other ferrous and non-ferrous metals. Stainless steel is used both for pens and for other products made to customers' orders; the other materials are stocked solely to meet customers' requirements.

FOLLOW-ON TOOLS

The first operation in the production sequence is carried out in power presses with follow-on tools, usually four-stage. A typical pair of tools would perform in sequence piercing (that is, cutting the slot which is found behind the pen

Much work is done to-day on power presses, but hand presses still have their uses. Among other advantages they are cheap, and many can be kept set up ready for the operators to move on to them, reducing waiting time.

Cleaning and polishing of pens and other small pressings has to be very thorough. It is done by barrelling with various abrasives and polishing materials for periods of 24 hours or more.

point), side slitting (making the slits which help the pen to be flexible), marking (stamping the makers' name and any other details required), and finally, blanking. Similar tools are used for many other products, the number of stages being modified accordingly. Fountain pen clips, for example, are made in three-stage tools, which pierce, mark and blank.

Pen blanks (and other products when necessary) are next annealed, stainless steel being the exception. Annealing is done in an electric pot-type furnace, with a controlled neutral atmosphere, which gives a clean, bright product, ready for the next operation.

HAND PRESS WORK

The pierced, side-slit and marked blank, which is flat, has next to be raised, or rounded to the familiar pen form. This introduces complications. It will be appreciated that it is quite feasible for follow-on tools to be designed so that the raising can be done in the power press following the blanking operation, but to do this the steel would have to be too soft for really high-class blanking, and the forming of the all-important precision point. To carry out the first four operations in the hard-rolled condition, followed by annealing to soften the steel sufficiently for raising is the obvious answer, and this is, in fact, what is done, but the operation of raising is not so simple as it looks.

There are two methods of raising at present in use. A power press with a hand feed is perfectly satisfactory, though great care has to be taken to see that one blank does not ride on another, as happens very easily. If two blanks were to enter the press simultaneously the tools, on a fixed-stroke machine, would be likely to be damaged. The ultimate solution to the problem, a power press with a hopper feed, is in the process of development, but this also raises its problems, for the blanks must not only be fed to the tools singly, but pointing in the right direction, and with the marking the correct way up. The shape of the blank offers little enough for a hopper sorting device to work on, and the marking even less.

Meanwhile, there is an alternative item of equipment, which is as old as the industry itself, but has much to commend it; this is the hand press. Large numbers of these simple machines are used for raising, and also for a further operation, slitting, to which reference is made later. The presses are all of the well-known screw or "fly" type.

Hand presses, though they need the services of that most expensive of commodities the human operator, are nevertheless capable of considerable economies. They are cheap and have negligible maintenance costs. Their tooling is simple and cheap, and will not normally suffer damage if two blanks should be fed together. Operators can be trained to use the presses very easily. Because the capital cost of providing and tooling hand presses is low, numbers can be kept set up for different operations, the labour moving round as necessary. Waiting time for hand-press operators in the Gillott factory is actually less than 1 per cent. of the total working time.

The presses are equipped with simple tools and have compressed air jets for ejecting the pens after raising, the jets being controlled by a valve worked by the press fly as it is returned to make a fresh stroke. Raising will be followed by a further hand press operation, rounding, in the case of certain pens such as those used for mapping, which have a tubular shank into which the pen holder is pushed.

HEAT TREATMENT

Hardening of steel pens has probably undergone more radical changes than any other single operation in the production sequence. Originally it was done with coal-fired equipment; in comparatively recent years it has been done in gas-fired muffles. To-day all Gillott pens and other products are hardened in a shaker-hearth electric furnace with a controlled neutral atmosphere and a sealed quench tank, the hardened product coming out of the quench perfectly free from oxidation, and needing only to be degreased before tempering. Trichlorethylene is used for degreasing.

Tempering still has something in common with the earlier methods, in that it involves the use of considerable skill by the operator. It is done in large batches of about 100 gross of pens at a time. Steel drums, rotated slowly with their axes horizontal, are heated from below by gas jets, and the batch is tipped into one of these drums, where it is heated slowly and uniformly, watched carefully by the operator, who extracts a pen from time to time and tests it by flexing the point. The barrel is emptied by tilting it when the required temper is reached. Specifications for pens and other products often call for tempering to a specified Vickers Pyramid hardness value, and this requirement is met without difficulty.

CLEANING AND FINISHING

After the tempering, which naturally causes some surface colouring of the pens, two cleaning operations follow. This work has to be done thoroughly to give the fine finish required, and to remove any trace of roughness from the whole of the pen surface, but it must also be reasonably gentle so that no damage is done to the fine point. The pens are first scoured in rotating steel barrels, 100 gross at a time, with sand and water for about 24 hours. They are then transferred to similar barrels, but this time with an oil and stone compound, for a further 24 hours, and here the pens receive their final polish.

Following the cleaning operations comes grinding, in two stages, across the point and along its centre-line to improve flexibility. This operation, which is done individually by hand on each pen, is not required on all pens, and some may pass straight from cleaning to the next operation, the important one of slitting. Once again the pens are taken, one by one, by hand, and dealt with in a fly press. Slitting, or the making of the slit from the point to the pierced hole, is done with a pair of shearing tools, the action being simply one of shearing, no metal being removed.

A barrelling in sawdust follows, to clean the pens after they have been handled for grinding and slitting, and they are then heat coloured in the tempering barrel if required, and finally lacquered by dipping in bulk, centrifuging, and barrelling while drying to prevent them from sticking together. The last operation of all is inspection, which is done on a statistical analysis basis. Other products also pass to the inspection department, their treatment there being according to the procedure laid down by the customer.

TOOL MAKING

The tool room is another section of the steel pen factory which has undergone great changes in the long history of the trade. Many years have passed since the making of press tools was almost entirely a hand operation, but it is worth remembering that the pioneers like Joseph Gillott, who made large-scale production possible, were fortunate if they had even such a simple machine as a treadle lathe.

The equipment of the Gillott tool room to-day comprises all the machines which might be expected in such a department, including a Thiel punch shaper, a DoAll sawing machine and a Hilger optical projector. Perhaps the most important change in tool making for the pen trade has been the introduction of form grinding, which is done on a Jones-Shipman grinding machine with a Diaform attachment. Modern heat-treatment equipment has disposed of many of the problems of the older tool maker, but form grinding, which can be done from the solid in hardened and tempered steel, has been of even greater value in the making of small, high-precision tools. The tool-maker made the steel pen possible; to-day he retains his importance in a factory in which pens, though an important product, are only one of many different kinds of small precision pressing.

The key to pen production is the tool room, as it has always been. The equipment to-day includes such machines as a punch shaper, an optical projector, and a form grinder.

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SIMPLIFYING WEIGHING

Two new devices have been produced by the Richardson Scale Company, Clifton, New Jersey, United States, to ease the problems involved in weighing materials. One is a hopper designed for fluffy or sticky materials which do not flow easily, such as asbestos fibres or rubber crumbs. The hopper is designed as a bell shape with one straight side, leading to a variable-pitch screw feeder for the bottom discharge. Arrangements are available by which the weigh hopper can be discharged manually by push button, or automatically with a mercury magnetic cut-off. It is available in capacities ranging from 50 to 1,500 lb. The second device relates to high speed weighings, particularly for a bagging scale. One of this type has now operated for over 1,000,000 weighings at a rate of over 20 per minute. It is completely automatic, and runs unattended. Accuracy is reported as being within 2·8 oz. on a 50 lb. batch.

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FOUR CHANNEL BETA RAY THICKNESS GAUGE

A four-channel Atomat beta-ray thickness gauging equipment, the first to be produced by the Baldwin Instrument Company, Limited, Brooklands Works, Dartford, Kent, is being installed at one of the major British automobile-tyre factories; it will be used for measuring the thickness of the rubber coating on the cord base.

The instrument incorporates four standard Atomats in a robust casing giving ready access for servicing. The standard Atomat gauge was introduced in 1950, for measuring the thickness of a sheet material. A radioactive isotope and a detector head are placed on opposite sides of the sheet, and the amount of beta-radiation detected is proportional to the weight per unit area of the material.

Book Reviews

MECHANICAL AND ELECTRICAL

Applied Electrical Measurements. By ISAAC F. KINNARD. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (15 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (120*s.*)

With the spread of mechanisation there has been an inevitable increase in both the number of measurements made and the degree of accuracy to which they must conform. Furthermore the scope and complexity of measuring instruments has increased greatly. Whereas it was once sufficient for an instrument to give a visual indication of one variable, it is now often necessary for an instrument system not only to measure several variables simultaneously, but also to interrelate them and, if desirable, to make adjustment to the primary system in order to keep the variables within specified limits. Progress in any field of industry generally necessitates progress in instrumentation. Speaking at a recent annual lunch of the British Industrial Measuring and Control Apparatus Manufacturers Association, Mr. F. J. Erroll, M.P., Parliamentary Secretary to the Board of Trade, said that in recognition of the importance of the instrument industry to the economy of Great Britain, the Board of Trade had recently set up the Instrument Industry Advisory Committee, which is due to meet for the first time this year.

Measurements are chiefly the concern of the electrical engineer, because most measurements to-day are made electrically, and because it is generally an advantage to locate the indicating equipment at some distance from the quantity being measured—for the sake of the operator's health or to avoid influencing the conditions under which the measurements are being made—and the only efficient way of communicating information over any distance is by electricity. Yet to the engineer the rapid increase in instrumentation can lead to a state bordering on bewilderment. There is a great variety of techniques and the relation between them is often far from clear. More often than not, there are several methods of making a particular measurement and the choice of the correct one may depend on a variety of factors outside the experience of the individual engineer concerned. Often, too, the measuring equipment must operate in conjunction with other apparatus with which the engineer is not familiar.

Thus there is a need for a unified approach to the basic principles that govern the application of electrical instruments to the measurement of electrical and non-electrical subjects. The subject tends to become split into water-tight compartments, but it is possible to produce a coherent exposition, as Dr. Kinnard shows.

In keeping with the book's title, the emphasis is on measurements rather than on instruments. The first two-thirds of the book is concerned with the measurement of electrical quantities, and the remainder with that of non-electrical quantities. In the latter section, in addition to a general survey, there are chapters describing the particular techniques employed in the fields of light, heat, sound, statics and kinetics, liquids and gases, and time. Inevitably, even in a volume of 600 pages, there is a considerable degree of condensation. The treatment of inductance and capacitance is very brief and there is no mention of dielectrics, resonance-curve techniques, or microwave measurements. However, there is a bibliography with each chapter and the book is extremely readable, provided the reader has some knowledge of electronics. The mathematics do not intrude too much—a knowledge of simple differential equations is required—and the book may conveniently be read straight through. The second half of the book on non-electrical measurements, gives a comprehensive survey of this expanding branch of instrumentation, and it is unlikely that there is another book that covers the same ground. Nevertheless it has its limitations since the purpose of the book is to bring together the techniques of a wide variety of fields which it is not possible to go into great detail. Thus the book would not be the best, say, that a mechanical engineer could consult on a strain-gauge problem. But it would be very useful to anyone expecting to do a lot of work on instrumentation, for it will give an adequate background to the subject and enable him to see the interrelation of the parts to the whole.

Rationalised M.K.S. units are used throughout. There is a chapter, devoted to the theory of measurements, which considers the various systems of units, the theory of dimensions, and the meaning of the terms "accuracy," "precision," and "sensitivity." The generalised functional analysis of measurements is described and the various special terms in it defined in accordance with those expected to appear in the first revision of the American Standard Definitions of Electrical Terms. Also included is an introductory chapter on telemetering, a subject which lends itself very readily to measurement analysis. The printing and layout are good, the diagrams and tables being particularly clear.

* * *

MORE LB. PER SQ. IN.

High Pressure Technology. By EDWARD W. COMINGS. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (11.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (86*s.* 6*d.*)

The properties of matter under high pressure have been of considerable interest to physicists for over 150 years. Even as far back as 1826, Perkins published a paper in the *Transactions* of the Royal Society on the effect of pressures of up to 30,000 lb. per sq. in. on the compressibility of water and other fluids, and several of the techniques he employed have been rediscovered by later workers in this field. Since then, many investigations have been carried out on the effect of pressure on physical properties and on chemical reactions, culminating in the extensive work of Bridgman. Bridgman has reached pressures of 430,000 lb. per sq. in. in a chamber of reasonable size and has developed methods of taking electrical leads out of such a chamber, so that measurements of various kinds can be made. By submerging a second intensifier inside this chamber he has managed to reach pressures of 1,400,000 lb. per sq. in., but only in an extremely small chamber.

Much of the work so far devoted to this topic has been only of academic interest, except in the field of chemical engineering where it has been found that pressure has made some processes possible and, in other cases, has considerably increased the yield of the process. One well-known example out of many is the production of polyethylene from ethylene, which is carried out commercially at a pressure of about 22,000 lb. per sq. in. This is possibly one of the highest pressure production processes carried out at the present time, but, if it were to be commercially desirable, higher pressures could now be employed.

Though much experience has been accumulated on the design of high-pressure plant, there are still many features of design which depend on past experience and are not very amenable to precise analysis. Consequently, details of successful practice in the design of high-pressure equipment such as thick cylinders, sealing devices, valves, pressure gauges, etc., must form an important section of any book on high-pressure technology. The book under review gives much fresh information which has become available since the books written by Bridgman (1931), Tongue (1934) and Newitt (1940) were published. The first half of the book is devoted to this aspect and to experimental techniques; much useful information is given on pressure measurement, sealing of vessels, seals for rotating and reciprocating shafts, gas compression, thick cylinders, etc. A complete chapter is devoted to the extremely important question of safety and the author is to be congratulated for emphasising this aspect. It is to be regretted, however, that he has not considered the creep properties of metals and of high-pressure vessels, as these are a serious limitation to the temperatures which can be reached in high-pressure processes.

The last half of the book includes chapters on the physical properties of gases and liquids, chemical engineering unit operation, chemical equilibrium, chemical reactors and the synthesis of ammonia. It gives considerable details of the synthesis of ammonia—an excellent example of an industrial high-pressure process. Various appendices on properties of gases, liquids and solids, limits of flammability of gases and vapours, etc., will be of use to chemical engineers.

The book forms a valuable addition to those already published on this topic and it contains much of value to the specialist in the field, but it is also of considerable interest to all who are interested in high-pressure techniques.

* * *

NEW BOOKS

Motor Vehicle Mechanics' Textbook. By F. K. SULLY. *Temple Press, Limited, Bowling Green-lane, London, E.C.1.* (12*s.* 6*d.*)

The book is based on the syllabus of the City and Guilds of London Institute for the examination on motor vehicle service mechanics' work. It is intended for students entering for the award of the National Craftsmen's certificate in automobile technology. The first part includes chapters under the general headings of Calculations, Science and Drawing, and the second deals with Motor Vehicle Technology. Calculations start with basic units, and proceed to the consideration of force and energy. First angle orthographic projection receives a brief section. Motor vehicle technology is divided into sections dealing with the various parts of the car; the chassis; the front wheel assembly; the power unit; and then proceeds to consider the operation of the power unit. Separate sections are devoted to such items as the ignition system, brakes, gearbox and compression ignition engines.

Capstan and Turret Lathe Handbook. By F. J. CAMM. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2.* (25*s.*)

Since, according to the preface, capstan and turret lathes now constitute a separate branch of engineering, a volume specially devoted to instruction on their uses and handling is desirable. This book covers their construction, use of stops and the different operations that can be carried out with these modern machines of mass production.

Machine-Tool Automation by Electronic Control (Automatic Repetitive Operation and Positioning by Tape, Computer and Other Related Methods). *The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1.* (4*s.* 6*d.*)

Number 38 in the Yellow Back series, this volume deals with the various methods of automatic operation of machine tools by electronic control. Systems employing magnetic tape, perforated tape and positioning and measurement are described in detail.

Hopper Feeds as an Aid to Automation. (Design and Application of Automatic Feed Devices in the Machine Shop.) *The Machinery Publishing Company, Limited, National House, West-street, Brighton. 1.* (4*s.* 6*d.*)

Automatic operation of machine tools involves the provision of automatic feed systems for the workpieces. Hopper feeds with their selector mechanisms are discussed in general, and then hopper feeds for nuts and bottle caps are described in particular. The final chapter deals with the application of these feeds for production and inspection.

The Oil Engine Manual. Edited by D. S. D. WILLIAMS. *Temple Press, Limited, Bowling Green-lane, London, E.C.1.* (18*s.*)

The first edition of *The Oil Engine Manual* appeared some 16 years ago. Considerable developments have taken place since then and, as a result, this, the sixth edition, has been very largely re-written to bring it up to date. Part 1 is concerned with the

technical background, and covers such items as the history of development, operating principles, maintenance, power station layout and the utilisation of exhaust and jacket water heat in stationary plants. Part 2 is concerned with current British designs and is divided into seven sections, dealing with industrial, transport and traction types. In the third part are included statistics, standards and specifications.

Metallurgical Analysis by Means of the Spekker Photoelectric Absorptiometer. By F. W. HAYWOOD and A. A. R. WOOD. Second edition. *Hilger and Watts, Limited, 98 St. Pancras-way, London, N.W.1.* (40*s.*)

The speediness and high accuracy of the determination, by absorptiometric methods, of various elements in aluminium, copper, magnesium and zinc alloys, and in steels, have caused these methods to be widely accepted for routine analyses in metallurgical laboratories. This book describes the construction, operation, and maintenance of the Spekker photoelectric absorptiometer and contains detailed instructions for its use in determining the metals commonly occurring in alloys.

High Speed Diesel Engines. By ARTHUR W. JUDGE. Fifth edition. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (65*s.*)

Several new chapters have been added to the earlier editions of this work, and these deal, in particular, with supercharging, small vehicle engines, air-cooled engines, special purpose engines and starting. As with previous editions, the treatment of the subjects has been kept to an elementary standard as far as possible, in view of the purpose of the original volume which was to appeal to engineers, designers, draughtsmen and students. Special reference is made in this volume to traction, stationary and marine types.

Untersuchungen über die dreidimensionale Potentialströmung durch axiale Schaufelgitter. By THEO GINSBURG. No. 22 of "Mitteilungen aus dem Institut für Aerodynamik." *Verlag Leemann, Zürich, Switzerland.* (15.55 *Swiss francs.*)

This treatise is a theoretical and experimental investigation, carried out between 1953 and 1955 at the Zürich Institute for Aerodynamics, into the additional influences arising from the three-dimensional effect of the potential flow through axial blade lattices. The object is to evolve a simple method of calculation which permits of ascertaining these effects with certain turbine and pump blading having cylindrical boundaries, and to represent them in a velocity disturbance field. The problem is approached both by mathematical calculation of the angle eddy and by electrolytic measurements. Application of the results to the turbine theory is explained.

Stahldrahterzeugnisse. Vols. I and II. Edited by the Committee for Wire Processing of the Verein Deutscher Eisenhüttenleute. *Verlag Stahleisen m.b.H., Breite Strasse 27, Düsseldorf, Germany.* (70 *D.M.*)

These two volumes on steel wire products present a comprehensive survey of their uses, from the sewing needle and paper clip to the highest-grade cableways and balls or rollers for bearings. Each section, by a different writer, is devoted to a class of products for which the processing methods are fully described, including the necessary data for quality, dimensions and preliminary treatment of the wire to be used. Test methods and relative standard specifications are also given. The work does not go into the manufacture of wire itself but is intended for persons connected with its further processing. The products are grouped under: ropes; welding wire; constructional steel mesh; wires for stressed concrete; hardware and related products; vehicle accessories; spiral springs; balls and rollers; needles; chains; rivets; nails; netting; barbed wire; parts for spinning and weaving machines; and woven fabric and lattice.

Die Berechnung mehrfach abgespannter Mastgruppen. By DR. ING. KURT MIESEL. Part 12 of "Forschungshefte aus dem Gebiete des Stahlbaues." *Stahlbau-Verlag, G.m.b.H., Ebertplatz 1, Cologne Germany.* (13.50 *D.M.*)

This issue, No. 12 in the series "Research Publications on Steel Constructions," deals with calculations for multi-stressed groups of terminal poles. The method of calculation is given for a system where the poles are in line and it can be applied to other systems. After dealing with straining wires and their flexibility, and the longitudinal strains on groups of poles, the practical procedure for calculating is given, followed by data for determining the buckling strength. In addition to 23 diagrams and relative formulae, there are graphs with corresponding data, covering cable stresses due to wind and temperature, and the elasticity of the straining point. These supplement a text which would be of interest to practical designers of poles.

STRUCTURAL ENGINEERING ON THE CONTINENT

POST-WAR CONSTRUCTION IN STEEL AND PRESTRESSED CONCRETE

Two recent papers presented to the Institutions of Civil Engineers* and of Structural Engineers† respectively describe the present trends on the Continent in design and construction for bridges and other structures in prestressed concrete and in steelwork.

In the first paper, Mr. Y. Guyon gave a general review of prestressed concrete bridges built using the Freyssinet system on the Continent and elsewhere overseas. A comparison of quantities of materials (concrete and steel), in terms of square foot of deck area, was made for various types of bridge exceeding 120 ft. span, namely, simply supported continuous with equal and unequal spans, portals, bowstring arches and solid arches. The importance of obtaining the maximum degree of fixity at the supports for continuous spans was emphasised, as was the present tendency to use continuous beams or portal frames. The designs of cross-sections adopted were examined, particularly slab thickness, spacing and dimension of longitudinal beams and diaphragms. Simply supported beams were treated in terms of economic limits which were stated to be 160 to 180 ft. for this type of construction. Continuous beams with equal and unequal spans were considered and it was stated that the most economical arrangement was found in a combination of long flexible spans alternating with short comparatively rigid spans (the longest single span being approximately the same in either case); the ratio short span/long span should be less than $\frac{1}{2}$.

Encastré beams, cantilever bridges and arches were only briefly described but portals were treated in some detail. The advantage of portals —small depth/span ratio—was mentioned, but the practical difficulties involved for solid web portals—great depth over the supports and location of cables and anchorages—were also stated. This latter difficulty could best be solved, it was suggested, by the adoption of sloping legs which could be prestressed where necessary to eliminate tension in the concrete.

Foundations, including piers and abutments, were discussed and an interesting part of the paper described some examples of Freyssinet types of bearings, both hinged and roller. The latter part of the paper included references to methods of erection and quoted examples of the techniques adopted and also a discussion of the relative merits of pre-cast and in-situ concrete. The question of prestressing of portal legs and of foundations using flat jacks and wedges was described with particular reference to the bridges over the River Maine and at Caracas. Methods of adjusting the reactions for statically indeterminate structures to offset secondary deformations and so to obtain the design values of stresses or to create favourable reactions were illustrated in another section of the paper.

In the introduction to Mr. Godfrey's paper, on German Steel Bridges, read at the Institution of Structural Engineers, the different qualities of German steels for structural purposes, including reinforcement and prestressing, were described and a table was given setting out their chemical composition and physical properties. The relevant German standards covering bridge and structural work were also listed.

The major part of this paper was devoted to the development of bridge designing since 1945, when the Germans were faced with the problem of reconstructing over 3,000 bridges which had been destroyed or damaged during the war. Prior to the war there had been a tendency in Germany to design a number of members to act as a single unit of the bridge; this design technique had now been developed to such an extent that whole superstructures were designed as a single member. The majority of the bridges described were constructed either with steel decks which form the top flange of a box or cellular member or, alternatively, with a concrete deck designed to behave in conjunction with the steel main girders and cross girders (composite construction). The former type was used for longer spans where the reduction of dead load was a primary consideration; in this case the wearing surface was usually mastic asphalt with aluminium insulating foil. Examples were the bridges at Bonn-Beuel, Cologne-Deutz and Düsseldorf-Neuss, as well as that across the Sava at Belgrade, of which the longest span was 855 ft. These bridges had all been designed as continuous girders having a very small depth/span ratio. In the case of the earlier bridges the deck was formed of stiffened curved plates; the later bridges were designed with flat plate decks some of which were stiffened either by bulb flats or by U-shaped stiffeners. An interesting example of these recent steel-decked bridges was that over the Weser, at Porta, the main members of which are formed entirely from plates or flats.

As an experiment, one-half of the Werratal bridge was replaced by a bridge having a steel-plate deck with bulb-flat stiffeners and tests showed that it had a high degree of rigidity under test loading; the other half of this bridge was replaced in composite construction (according to DIN 1078), the effects of creep and shrinkage being allowed for by varying the value of the modular ratio. In cases where this form of construction was adopted for continuous girders it had proved necessary to prestress the concrete over the supports. This might be done by longitudinal wires in addition to the normal transverse prestressing wires but in some cases, for example, at Werratal, this prestressing was effected by erecting the steelwork with a negative camber before concreting and afterwards lowering or raising the bearings to their correct level.

Other examples of bridges described as being representative of type construction, included the bridge over the Neckar, where the bottom flange contained prestressing cables; the U-shaped bridge at Minden; the single-girder footbridge at Meppen; and the multiple-intersection lattice-girder railway bridge over the Rhine. Other major bridges mentioned were the suspension bridge between Cologne and Mulheim and the "bridle" suspension bridge between Duisberg and Homberg. The main girders of the latter consisted of box-section main girders carrying cross beams and deck plates reinforced by trapezoidal stiffeners. A striking feature of all the foregoing bridges was the economy in steel obtained as compared with the pre-war bridges which they replaced, even though the latter had to carry a lighter live loading.

The latter part of the paper was devoted to the description of developments in the design and construction of office blocks, exhibition buildings, sports arenas and industrial buildings. The structural sections available and methods of treatment of girder web stability were mentioned briefly. (The latter subject is also treated in the draft revision to B.S. 153). An interesting section of the paper dealt with the use of tubes for both office buildings and industrial structures and a suggestion for using tubes with internal prestressing wires.

The last part of the paper discussed the use of high-tension bolts, adopted in railway bridge and other structures because of the shortage of skilled riveters; advantage was also taken of applying an adhesive to the contact surfaces where this type of bolt is used.

* "Long-Span Prestressed Concrete Bridges constructed by the Freyssinet System," by Y. Guyon.

† "Post-War Developments in German Steel Bridges and Structures," by G. Bernard Godfrey.

IMPROVING GAS TURBINE PERFORMANCE

By B. W. Martin, M.SC., PH.D., A.M.I.MECH.E., A.F.R.AE.S.*

At present the gas turbine is only competitive with other prime movers in certain limited fields, and even there its advantages are largely marginal. If its application is to be extended, means must be found of increasing its efficiency and overcoming the limitations which still hinder its development. One approach is to raise the operating temperature; another is to use intercooling. These factors are examined in two articles published below, in which the author considers to what extent changes in the cycle conditions can yield improved performance, and the limits beyond which no improvement can be expected. The author recognises that to achieve the operating temperatures prescribed, liquid cooling of the heavily loaded turbine components may be necessary, but considers that this will not detract to any great extent from the gas turbine's inherent simplicity. (An article to be published later, likewise by members of King's College, University of Durham, will discuss a method of cooling turbine blades using a liquid metal—the closed thermosyphon.) The author also feels that insufficient attention has been given to the question of intercooling: although there has been wide discussion of its effect on cycle output with reference to division of compression work and the establishment of optimum conditions for both two-stage and multi-stage compression, its effect on thermal efficiency appears to have been neglected.

1—THERMAL EFFICIENCY AT HIGH TEMPERATURES

Summary

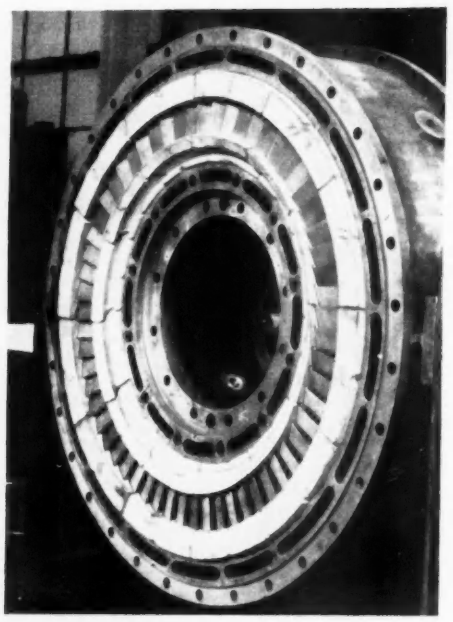
In the last decade the scale of application of the gas turbine to the field of industrial power production has fallen far short of original expectations. This can be partly attributed to the fact that the performance of existing industrial layouts and designs is not competitive. In this article the approximate limits of present performance are estimated, following which is an analysis of the potentialities and limitations of selected cycles at operating temperatures which necessitate cooling. It appears from the analysis that the inherent simplicity of the gas turbine can be combined with substantial improvements in performance over a specified temperature range.

Introduction

Among the assets possessed by the gas turbine may be included simplicity, flexibility of design, and a relatively high power-weight ratio. Yet in spite of these advantages, it has become increasingly evident in the last few years that the gas turbine will not have a significant place in the field of industrial power production unless its performance can be improved to such an extent that it is clearly superior in this respect to the older forms of prime mover. Particularly would this involve a fairly large increase in overall thermal efficiency, so as to decrease the running costs, but it would also be advantageous to raise the specific output and thus reduce the size of an installation for a given output, thereby helping to lessen the first costs. Provided the reliability of the gas turbine for long-life industrial purposes could also be established, the achievement of these objectives, without sacrifice of the advantages already enumerated, would help to ensure its more widespread use at sea and in power stations, and probably for locomotion by road and rail.

Present-day opinion inclines to the view that the most promising way of attaining the above objectives is through an increase in the highest cycle temperature. Brown (1954) has stated that, in practice, with present refractory materials, a gas turbine combustion chamber could withstand a maximum gas temperature of 3,500 deg. F. (1,930 deg. C.). But the extreme working temperature of the alloys used in long-life gas turbines is no more than 1,500 deg. F. (820 deg. C.) and even this is true of materials only available on a laboratory scale. Furthermore, it is unlikely that metallurgical advances will lead to any sudden and large increase in this order of temperature. The implication is, therefore, that no real improvements in performance can be expected, unless the components of the prime mover which are exposed to the highest gas temperatures can be effectively cooled to, or otherwise maintained at, working temperatures in the range 1,200 to 1,400 deg. F. (650 to 760 deg. C.).

Cooling problems in the ducting and stationary components of the turbine, which are comparatively lightly stressed, can usually be fairly readily solved. One method is to provide such components with refractory lining, or to build them wholly of ceramic. This has been done in the case of the Pametrada experimental high-temperature gas turbine, certain details of which are illustrated in Figs. 1 and 2. There are a number of possible ways in which the metal of the heavily-loaded rotor blades and drum might be maintained at a satisfactory temperature level. These include the application, where necessary, of ceramic coatings, while there are two well known methods of utilising the cooling properties of part of the air leaving the compressor. For the highest turbine inlet temperatures, where it is contended that air cooling would be inadequate, there are several promising alternatives in which liquids are involved. But whichever method or combination of methods is adopted, the heat transferred by convection and radiation from the hot gas represents a loss of highly available



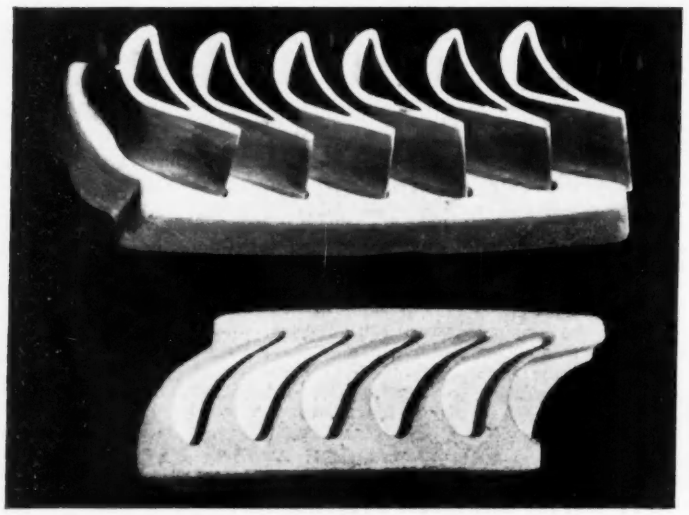


Fig. 2 (above) Detail of ceramic stator blading shown in Fig. 1. The rotor, which is subjected to high centrifugal loading, has hollow metal-alloy blades cooled by liquid-metal convection.

Fig. 1 (left) Casing and ceramic nozzle blades for high-temperature liquid-cooled gas turbine under investigation at the Pametrada Research Station. Cycle temperatures of 1,200 deg. C. are envisaged.

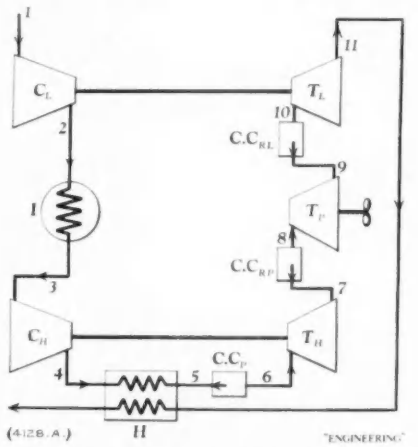


Fig. 3 Circuit diagram of double-compound uncooled gas turbine.

C_L	low-pressure compressor.	T_H	high-pressure turbine.
I	intercooler.	CC_{RP}	first reheat chamber.
C_H	high-pressure compressor.	T_P	power turbine.
H	heat exchanger.	CC_{RL}	second reheat chamber.
CC_P	primary combustion chamber.	T_L	low-pressure turbine.

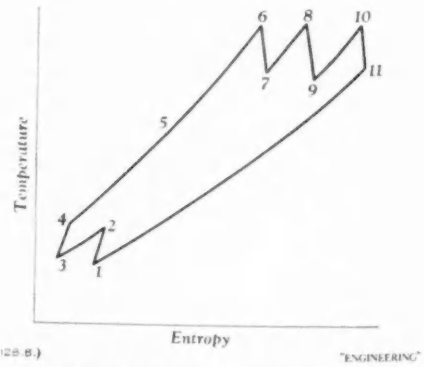


Fig. 4 Temperature-entropy diagram for uncooled gas-turbine cycle.

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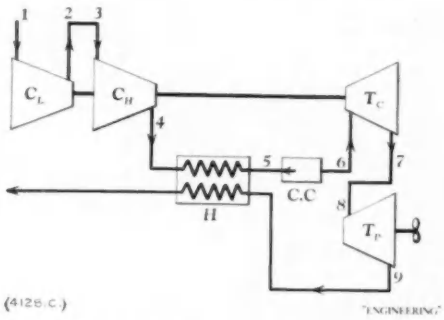

Fig. 5 Diagram of cooled gas-turbine circuit.

C_L low-pressure compressor. CC combustion chamber.
C_H high-pressure compressor. T_C compressor turbine.
H heat exchanger. T_P power turbine.

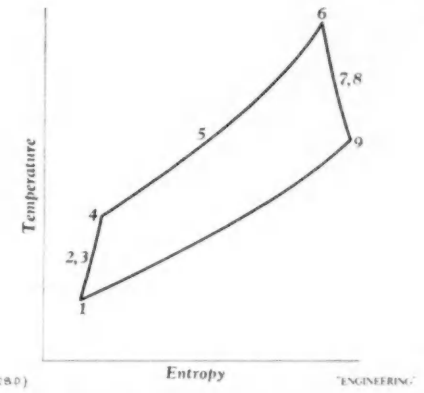

Fig. 6 Temperature-entropy diagram for cooled gas-turbine cycle. The corresponding circuit diagram is shown in Fig. 5 above.

thermal energy. This cooling loss has an adverse effect on the performance of the gas turbine, though the effect may be mitigated by transferring the energy to some auxiliary cycle capable of developing further power.

Scope of Analysis

The purpose of this article is first to assess the full-load performance of a fairly complex but uncooled type of gas-turbine cycle, which might reasonably be said to represent the approximate limit of practical possibility, having regard to manufacturing costs. Since the cycle is uncooled, the maximum cycle temperature is restricted to 1,430 deg. F. (777 deg. C.), with a suitable pressure ratio. If the performance of this cycle may be regarded as the best attainable in practice without cooling, it can be used as a standard of reference against which other cycles employing cooling may be compared. Thus the consequent improvement (if any) in performance can be assessed. The author believes that the conception of a high-temperature gas turbine is justified on several scores, not least of which is the opportunity it provides to reverse as far as possible the trend towards complexity of layout. One of the most important assets of the gas turbine would thus be retained. For this reason the full-load performance is examined of only the simplest cooled cycles. Allowance is made for cooling loss, but in order to obtain a fair comparison, operating conditions are otherwise identical with those of the uncooled but more complex cycles.

Design Assumptions

Overall pressure ratio, 15 to 1; compressor isentropic efficiency, 85 per cent.; turbine isentropic efficiency, 85 per cent.; heat-exchanger thermal ratio, 70 per cent.; specific heat of air during compression, 0·24; isentropic index of air during compression, 1·40. The physical properties of air at elevated temperatures have been obtained from the *Gas Tables* of Keenan and Kaye.

Performance of Uncooled Cycle

The uncooled double-compound cycle selected for examination is shown in Fig. 3, while Fig. 4 is the corresponding temperature-entropy diagram. The high-pressure turbine drives the high-pressure compressor, and the low-pressure turbine drives the low-pressure compressor. The uncoupled power turbine is in the gas circuit between the two compressor turbines and the performance of the basic cycle is improved as far as possible by the inclusion of an intercooler and heat exchanger, with reheat to the maximum cycle temperature of 1,430 deg. F. (777 deg. C.) before the power turbine and the low-pressure turbine. It is assumed that the total work of compression is shared equally between the compressors. The performance of this cycle over the whole load range but for slightly different conditions has been examined in detail by the author (1948) and discussed by Mallinson and Lewis (1948). It has been found to have satisfactory characteristics for marine installations, and where a heat exchanger is included the full-load thermal efficiency is maintained down to half-load. In a further discussion of the cycle, Brown points out that the low-pressure compressor-turbine combination can be regarded as a supercharger which can be put out of action during part-load running. The cycle is chosen as being among the most complex layouts which have yet been seriously considered for practical use.

The author's previous examination of the full-load performance of the cycle, based on the same maximum temperature but assuming rather better component efficiencies and an overall pressure ratio of 12 to 1, gave a thermal efficiency of 34·2 per cent. and a specific output of 159 b.h.p. per lb. of air per second. This included allowances for pressure losses in the system, incomplete intercooling and mechanical transmission losses. Making similar allowances in the present case, the full-load performance is estimated as 33·6 per cent. thermal efficiency (specific consumption 0·4 lb. per b.h.p. per hour) and about the same specific output as before. This data will, therefore, be used as a standard of comparison in what is to follow.

Performance of Cooled Cycles

Figs. 5 and 6 show, respectively, the circuit diagram and the temperature-entropy diagram for one of the two cooled cycles to be examined. The other cycle differs from the one shown in Fig. 5 in one respect only; it does not include a heat exchanger. Its part-load performance has been assessed by Mallinson and Lewis and, for a maximum temperature of 1,430 deg. F., (777 deg. C.) appears satisfactory. Apart from the simplification brought about by using only one compressor-turbine combination, the cycle uses neither reheat nor intercooling. It is contended that since these modifications increase the specific output rather than, and sometimes at the expense of, the thermal efficiency, it is desirable that they be excluded from the cooled high-temperature cycle, by which it is intended to improve the performance as a whole. The overall pressure ratio is retained at 15 to 1 not only for comparative purposes, but also because an appreciable increase, while perhaps slightly improving the performance, would in practice tend to reduce the margin of advantage which the gas turbine has in respect of requisite strength of pipes and joints over high-temperature high-pressure steam plant. A large increase in pressure ratio would also involve a rather more complex compression process.

The effect of reducing the compression ratio is, however, to bring about an increase in cooling-loss factor, which is defined by Brown (1950) as the ratio of heat loss to work done in a given turbine stage. The cooling loss factor is also an increasing function of maximum cycle temperature, and, in view of the limiting gas temperature which it has been suggested a combustion chamber could withstand, the present analysis covers the range between 1,400 deg. F. and 3,500 deg. F. (760 and 1,930 deg. C.); it is assumed that over this range the cooling loss factor increases in the manner portrayed by Brown from 6 to 30 per cent. This represents a slightly more conservative view of the heat loss than might be suggested from a double extrapolation of Brown's estimates, especially at the higher temperatures. This assessment arises from the author's lower evaluation of the probable convective loss to the blades (1955), which is based on Ainley's investigation (1953) of an air-cooled turbine. But, of course, any estimate of cooling loss temperature variation depends very much on turbine design and must at the present time be regarded as tentative.

Fig. 7 shows the variation of estimated thermal efficiency of the two cycles assuming that the thermal energy extracted by cooling is wasted; Fig. 8 shows the overall effect of using this energy in an auxiliary cycle which is assumed to have an efficiency of 30 per cent. Fig. 9 illustrates the effect of maximum temperature on specific output for both cooled cycles, the small change in output due to inclusion of a heat exchanger being neglected. Allowance is, however, made for pressure losses in the other components and ducting, and for transmission loss.

It emerges from Figs. 7 and 8 that, given realistic data, a heat exchanger is essential if there is to be any substantial improvement in thermal efficiency; in fact the cycle without a heat exchanger in which the heat extracted by cooling is thrown away, actually has a lower thermal efficiency than that of Fig. 3 over the whole temperature range considered. Furthermore, it is only just possible to achieve 40 per cent. thermal efficiency *with* a heat exchanger where the energy from cooling is wasted. But, given an auxiliary power cycle, there is no doubt of the improvement in overall efficiency, which exceeds 45 per cent. (specific consumption 0·30 lb. per b.h.p. hour) at the highest temperatures. The efficiency of the same cycle (shown in Fig. 5), assuming no cooling, ranges from 36·3 per cent. at 2,000 deg. F. (1,093 deg. C.) to 50·7 per cent. at 3,500 deg. F. (1,927 deg. C.).

The shape of the four curves suggests, however, that there is no commensurate gain by exceeding

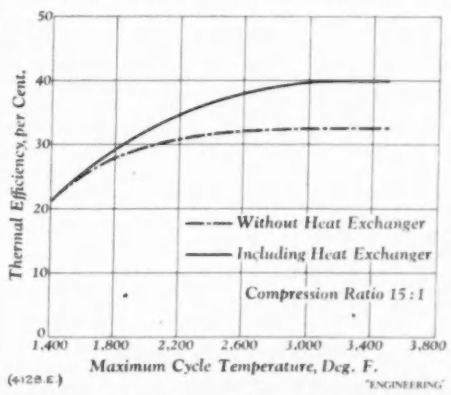

Fig. 7 Relationship between cycle thermal efficiency and maximum temperature when thermal energy is extracted by cooling and goes to waste.

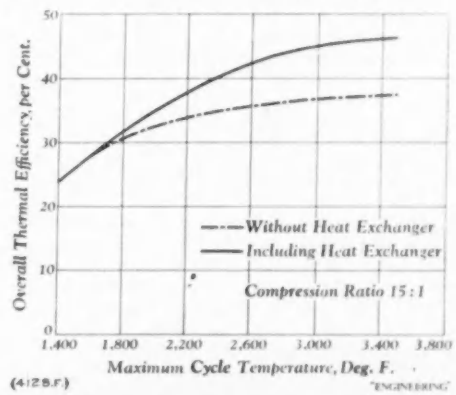

Fig. 8 Improved overall efficiency due to utilisation of extracted thermal energy in auxiliary cycle, with an assumed efficiency of 30 per cent.

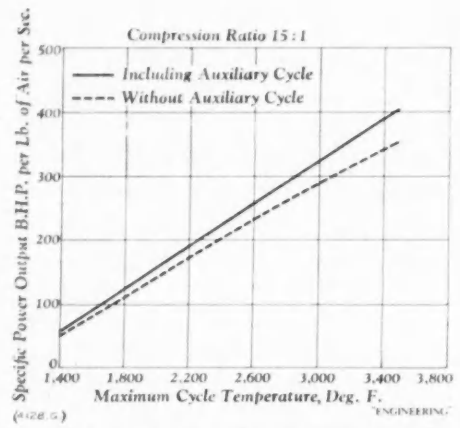

Fig. 9 Variation of specific output with maximum cycle temperature for both cooled cycles.

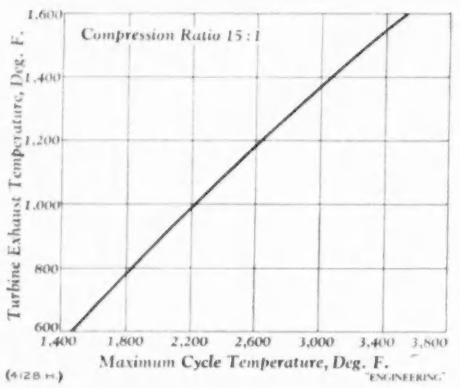

Fig. 10 Variation of turbine exhaust temperature with maximum cycle temperature.

3,000 deg. F. (1,650 deg. C.) even if this should be possible; moreover, there is some danger that unless large compression ratios are used the turbine exhaust temperature would be so high that further cooling would be needed before the hot gases could be passed through a heat exchanger without ultimate damage to the latter. This is shown in Fig. 10, where turbine exhaust temperature is plotted against maximum cycle temperature. Such further cooling, even if utilised in the auxiliary cycle, would reduce the thermal efficiencies shown in Fig. 7 and 8, and would probably lead to a definite maximum in the region of 3,000 deg. F. (1,650 deg. C.), thus strengthening the argument against exceeding this temperature.

The relationship between specific output and maximum cycle temperature is seen to be roughly linear (Fig. 9). The specific output is the same as for the uncooled cycle (159 b.h.p. per lb. of air per second) at a temperature between 2,000 deg. F. (1,093 deg. C.) and 2,100 deg. F. (1,149 deg. C.), while at 3,000 deg. F. (1,650 deg. C.) there is a gain of over 100 per cent. if an auxiliary cycle is used. This significant improvement means that much could be done to reduce the size of the components used in developing a given power.

Concluding Remarks

If the underlying theme of the present article is correct, that development of the high-temperature gas turbine should be coupled with the use of the simplest possible operating cycles, the conclusion then seems inescapable that no perceptible improvement in present-day performance can be expected for maximum temperatures below 2,000 deg. F. (1,093 deg. C.). Furthermore, for the gains to be really worth while, the aim should be to operate successfully at temperatures in the range 2,500 deg. F. (1,370 deg. C.) to 3,000 deg. F. (1,650 deg. C.), preferably with a bias towards the latter figure. If cooling losses at the highest temperatures have been underestimated, which may well be the case, the true relationship between thermal efficiency and maximum temperature should tend towards a peak value, probably at around 3,000 deg. F. (1,650 deg. C.). All the indications are, therefore, that there is nothing to be gained and perhaps something to lose, by exceeding this temperature, for even if cooling losses have been overestimated (rather than the reverse), the improvement in thermal efficiency with temperature in this region is likely to be minute.

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2—THE EFFECT OF INTERCOOLING ON EFFICIENCY

Summary

This article seeks to establish, in quantitative terms, the conditions under which the thermal efficiency of the simple gas turbine is improved, reduced, or remains unchanged by the addition of intercooling to the cycle. The investigation (which takes account of component efficiencies and variation of specific heats with temperature) shows, among other things, that above a certain maximum temperature the plain cycle has a better efficiency than the equivalent intercooled cycle, but that at the highest maximum temperatures the performance of the two arrangements does not differ appreciably.

Introduction

The fundamentals of gas turbine technology are now so widely known, due to the works of such authors as Thomson (1948), Cohen and Rogers (1951), Hodge (1955), Roxbee Cox (1955) and others, that the main reasons for the changes in performance due to the addition of heat exchange, reheat, and intercooling to the simple cycle are generally appreciated. Heat exchange improves the thermal efficiency of the cycle but not the power output per pound of air, while reheat raises the output but simultaneously reduces the efficiency. Heat exchange and reheat together increase both output and efficiency, and this is true also of heat exchange with intercooling, or a combination of all three of these modifications. An interesting case which does not appear to have received any special attention is that of intercooling by itself. While the net output is raised due to the reduction in total compression work, intercooling has the additional effect of lowering the final compression temperature, and thus of increasing the heat to be added in the combustion chamber. It therefore depends on the relative magnitude of the two increases whether the thermal efficiency is raised or lowered, or remains unchanged.

It is the object of this article to ascertain the conditions which govern these changes, and to determine their order of magnitude for operating conditions likely to be encountered in practice. Some idealisation is necessary to reduce the problem to reasonable proportions, and so it is assumed that when intercooling is considered, the isentropic efficiency and work input of each of the two compressor stages is the same. The treatment has not been extended to cover the case of multiple intercooling with more than two compression stages, as this is considered to be almost outside the range of practical possibility unless very large pressure ratios are contemplated. It is also assumed that cooling to the initial air temperature is complete, and that there is no pressure loss in the intercooler, in the combustion chamber, or in any of the ducting between components. The combustion and mechanical transmission efficiencies are taken to be 100 per cent. Fortunately these approximations introduce only minor departures from the values likely to be obtained in practice. The effect of change of specific heat with temperature is considered at a later stage in the text, after the primary governing conditions have been deduced.

Notation

T	absolute temperature.	η_c	compressor isentropic efficiency.
t	cycle overall temperature ratio.	η_T	turbine isentropic efficiency.
R	cycle pressure ratio.	η	cycle thermal efficiency.
γ	ratio of specific heats.	W	cycle net work output per lb. of air.
C_p	specific heat at constant pressure	Q	heat input per lb. of air.

Suffixes " p " and " i " refer to the plain and intercooled cycles respectively.

Analysis of Plain Cycle

The gas circuit and temperature-entropy diagram for the plain cycle are shown in Figs. 11 (*a*) and 11(*b*) respectively. The net output per lb. of air is given by

$$W = C_p(T_3 - T_4) - C_p(T_2 - T_1)$$
$$= C_p\left[\eta_T T_3\left(1 - R^{\frac{1-\gamma}{\gamma}}\right) - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{\gamma}} - 1\right)\right] \quad . \quad . \quad . \quad (1)$$

while the heat input per lb. is

$$Q = C_p(T_3 - T_2)$$
$$= C_p\left[T_3 - T_1 - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{\gamma}} - 1\right)\right].$$

The cycle thermal efficiency is then represented by

$$\eta_p = \frac{W}{Q} = \frac{\eta_T T_3\left(1 - R^{\frac{1-\gamma}{\gamma}}\right) - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{\gamma}} - 1\right)}{T_3 - T_1 - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{\gamma}} - 1\right)} \quad . \quad . \quad . \quad (2)$$

where R is the cycle pressure ratio.

Analysis of Intercooled Cycle

The arrangement of components for the intercooled cycle is shown in Fig. 12 (*a*), and the corresponding temperature-entropy diagram in Fig. 12 (*b*). Since the condition for minimum total compression work is assumed in a cycle where the pressure ratio is R, the pressure ratio

C compressor.
CC combustion chamber.
T turbine.

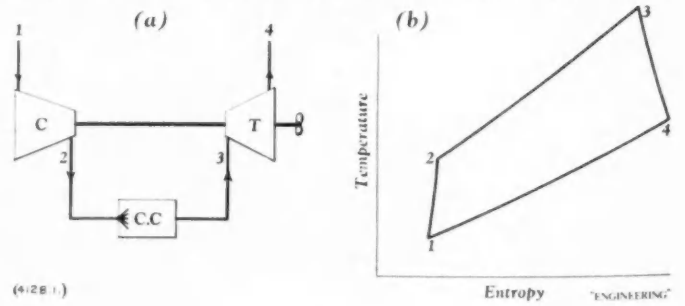

Fig. 11 Circuit diagram and temperature-entropy diagram for plain gas-turbine cycle.

in each compression stage is $R^{\frac{1}{2}}$. It should also be noted that $T_5 = T_1$ and $T_6 = T_2$. The net output of work per lb. of air is then

$$W = C_p(T_3 - T_4) - 2C_p(T_2 - T_1)$$
$$= C_p\left[\eta_T T_3\left(1 - R^{\frac{1-\gamma}{\gamma}}\right) - \frac{2T_1}{\eta_c}\left(R^{\frac{\gamma-1}{2\gamma}} - 1\right)\right]. \quad . \quad . \quad . \quad (3)$$

The heat input per lb. is

$$Q = C_p(T_3 - T_6)$$
$$= C_p\left[T_3 - T_1 - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{2\gamma}} - 1\right)\right].$$

As before, the thermal efficiency is given by

$$\eta_t = \frac{W}{Q} = \frac{\eta_T T_3\left(1 - R^{\frac{1-\gamma}{\gamma}}\right) - \frac{2T_1}{\eta_c}\left(R^{\frac{\gamma-1}{2\gamma}} - 1\right)}{T_3 - T_1 - \frac{T_1}{\eta_c}\left(R^{\frac{\gamma-1}{2\gamma}} - 1\right)} \quad . \quad . \quad . \quad (4)$$

Conditions Governing Cycle Efficiency Changes

It is convenient to write $K = R^{\frac{\gamma-1}{\gamma}}$, and to make the following substitutions.

Let

$$A = \eta_T T_3\left(1 - \frac{1}{K}\right), \quad B = \frac{2T_1}{\eta_c}(K^{\frac{1}{2}} - 1)$$

and

$$C = (T_3 - T_1), \quad D = \frac{T_1}{\eta_c}(K - 1).$$

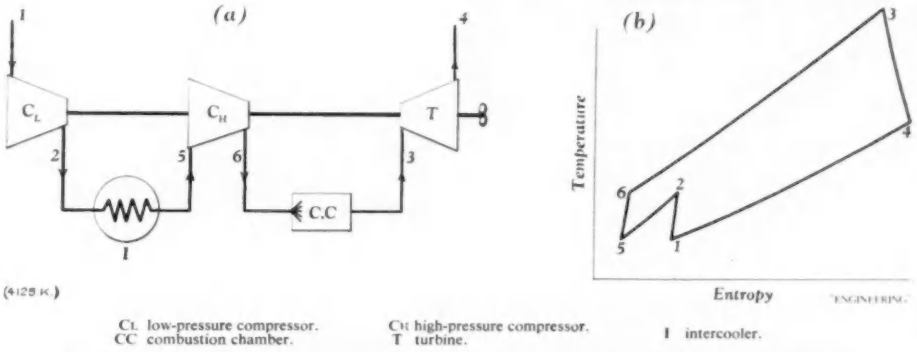

Fig. 12 Circuit diagram and temperature-entropy diagram for intercooled gas-turbine cycle.

Then $B(K^{\frac{1}{2}} + 1) = 2D$.

Reference to equations (2) and (4) shows that the plain cycle will then have the greater thermal efficiency if

$$\frac{A - D}{C - D} > \frac{A - 2D/(K^{\frac{1}{2}} + 1)}{C - D/(K^{\frac{1}{2}} + 1)} \quad . \quad (5)$$

This inequality can be reduced to

$$AK^{\frac{1}{2}} + C(1 - K^{\frac{1}{2}}) > D \quad . \quad (6)$$

Resubstitution for A, C and D leads ultimately to the condition that the cycle overall temperature ratio $t = \frac{T_3}{T_1}$ must satisfy the inequality

$$t > \frac{K + K^{\frac{1}{2}}(1 - \eta_c)}{\eta_c[\eta_T - K^{\frac{1}{2}}(1 - \eta_T)]} \quad . \quad (7)$$

This can be interpreted as meaning that for fixed component efficiencies and a given pressure ratio, the plain cycle will be the more efficient if the maximum cycle temperature exceeds a particular value, determined from (7). This, of course, assumes that the minimum cycle temperature is constant; it will be taken as 288 deg. K. in what follows. In Fig. 13 the maximum cycle temperature thus determined is seen to increase when plotted against pressure ratio for different values of compressor efficiency and turbine efficiency. That these last two parameters do not exert equal influence is shown by the curves representing the three conditions (*a*) $\eta_c = \eta_T = 0{\cdot}85$, (*b*) $\eta_c = 0{\cdot}9$, $\eta_T = 0{\cdot}8$, (*c*) $\eta_c = 0{\cdot}8$, $\eta_T = 0{\cdot}9$, which, had this been the case, might have been expected to be coincident.

The figure confirms what is already well known, namely that intercooling is more likely to have a beneficial effect on the thermal efficiency of a cycle with low component efficiencies than on one where the component efficiencies are high. Because the two efficiencies do not exert the same influence, any benefit to the cycle efficiency will be greater with a low turbine efficiency than with the same value of compressor efficiency. It is, in fact, obvious from (7) that when the turbine efficiency falls to such a value that

$$\eta_T = \frac{K^{\frac{1}{2}}}{K^{\frac{1}{2}} + 1} \quad . \quad . \quad (8)$$

the value of t, and hence of T_3 (at which the plain cycle attains a superior efficiency) becomes infinitely large. Thus the intercooled cycle is then always the more efficient, irrespective of the compressor efficiency.

Equation (8) is plotted in Fig. 14, from which the flat nature of the curve makes it clear that this limiting condition corresponds to a turbine efficiency of the order of 60 per cent. over a wide range of pressure ratios from about 9 to 30. (Inspection of (7) shows that there is no such limiting condition in the case of the compressor efficiency.) While the turbine efficiency quoted is much lower than would normally be tolerated in a practical case, it is still perfectly possible for both plain and intercooled cycles to produce positive work. Fig. 13 also confirms that for given component efficiencies and a fixed maximum cycle temperature an increase in pressure ratio will increase the likelihood of the intercooled cycle being the more efficient, if it does not actually make it so.

The above analysis is incomplete, because there are additional limitations imposed by the fact that the cycles must produce positive work. This condition is given by equation (1) for the plain cycle, which can be expressed as

$$t > \frac{K}{\eta_c \eta_T} \quad . \quad . \quad . \quad (9)$$

For the intercooled cycle equation (3) yields

$$t > \frac{2}{\eta_c \eta_T}\frac{K}{(K^{\frac{1}{2}} + 1)} \quad . \quad . \quad (10)$$

It may be readily shown that

$$\frac{K}{\eta_c \eta_T} > \frac{K}{\eta_c \eta_T}\frac{2}{(K^{\frac{1}{2}} + 1)} \quad . \quad (11)$$

and, in addition, for positive values of K and for values of η_c and η_T less than unity, it can be shown that the right hand side of (7)

$$\frac{K + K^{\frac{1}{2}}(1 - \eta_c)}{\eta_c[\eta_T - K^{\frac{1}{2}}(1 - \eta_T)]} > \frac{K}{\eta_c \eta_T} > \frac{K}{\eta_c \eta_T}\frac{2}{(K^{\frac{1}{2}} + 1)} \quad . \quad . \quad . \quad (12)$$

from (11). We therefore conclude that the plain cycle has the better efficiency when (7) holds good, but that the intercooled cycle is best in the restricted range such that

$$\frac{K + K^{\frac{1}{2}}(1 - \eta_c)}{\eta_c[\eta_T - K^{\frac{1}{2}}(1 - \eta_T)]} > t > \frac{2}{\eta_c \eta_T}\frac{K}{(K^{\frac{1}{2}} + 1)} \quad . \quad . \quad . \quad (13)$$

These conditions are illustrated in Fig. 15 for the case where the component efficiencies are each 0·85. The range of temperatures and the absolute values for which the intercooled cycle yields the higher efficiency with positive output are seen to increase with pressure ratio. Also shown in the graph is the effect of taking into account the variation of specific heats with temperature. The generally accepted method is used of substituting a mean value of 0·274 in place of 0·240 for the specific heat of air at constant pressure during heating and expansion, with a corresponding reduction in isentropic index from 1·40 to 1·333. Only at the higher pressure ratios does this correction exert an appreciable effect on the range of temperatures in which the intercooled cycle has the better efficiency. Even then the lower absolute level of temperature (the condition for positive work) is virtually unchanged. At a pressure ratio of 16, the upper temperature above which the plain cycle is superior, can now be more accurately determined as 1,310 deg. K, compared with 1,130 deg. K when specific heat variation is ignored. The discrepancy is, however, less than 100 deg. C. for pressure ratios below about 10.

Reverting to Fig. 13, it should be noted that in the special case of ideal component performance, such that $\eta_c = \eta_T = 1{\cdot}0$, inequalities (7) and (9) both reduce to

$$t > K, \text{ i.e., } \frac{T_3}{T_1} > R^{\frac{\gamma-1}{\gamma}} = \frac{T_2}{T_1} \quad \text{or} \quad T_3 > T_2$$

This implies that the condition for superiority of the plain cycle does not hold good in the

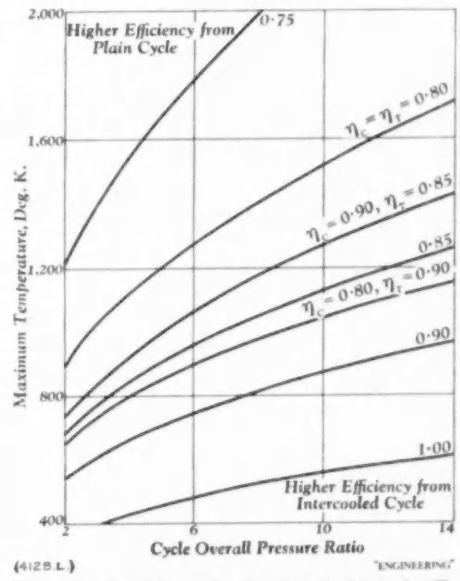

Fig. 13 Conditions for increased thermal efficiency for various values of component isentropic efficiency (max. cycle temp. and pressure ratio).

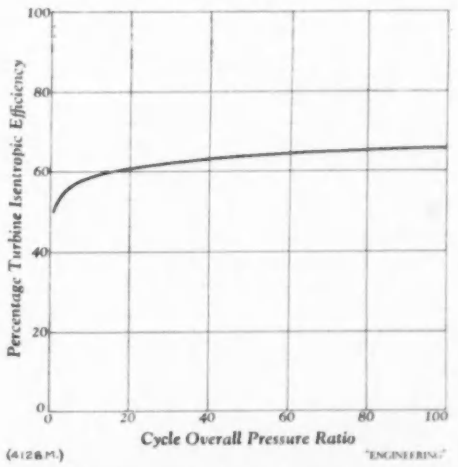

Fig. 14 Values of turbine efficiency below which the intercooled cycle is always the more efficient.

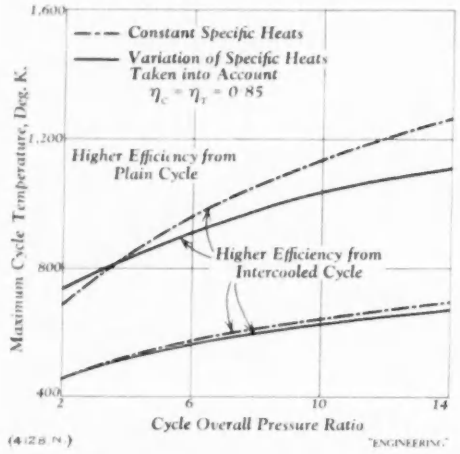

Fig. 15 Conditions for superior thermal efficiency for plain and intercooled cycles.

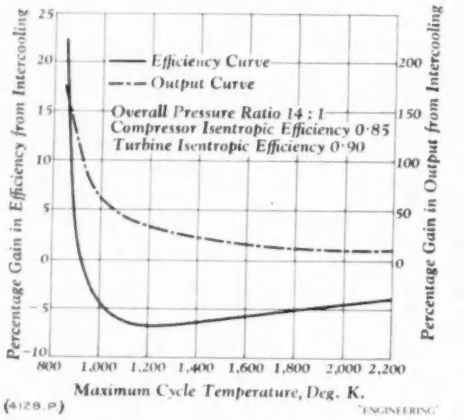

Fig. 17 Changes in efficiency and output as a result of intercooling.

hypothetical limiting case when no heat is supplied.

Cycle Efficiencies

It is desirable first to obtain an expression corresponding to equality of efficiency between the plain and intercooled cycles. This may easily be done by substituting the equation resulting from (7

$$\frac{T_3}{T_1} = \frac{K - K^{\frac{1}{2}}(1-\eta_c)}{\eta_c[\eta_T - K^{\frac{1}{2}}(1-\eta_T)]}$$

into (2) or (4). After some simplification we find that

$$\eta = 1 - K^{-\frac{1}{2}} = 1 - \frac{1}{R^{\frac{\gamma-1}{2\gamma}}} \quad . \quad (14)$$

which happens also to be the thermal efficiency of the ideal constant-pressure or Joule cycle with a pressure ratio of $R^{\frac{1}{2}}$. A surprising feature of (14) is that it is independent of both the overall temperature ratio t and the component efficiencies η_c and η_T, the efficiency being a function only of the pressure ratio and the isentropic index. The lower curve in Fig. 16 shows the effect of taking into account the variation of specific heats. At a pressure ratio of 10, the thermal efficiency of both cycles is about 28 per cent. for constant specific heats, which must be compared with 25 per cent. when the correction for specific heats is applied.

The order of percentage change in thermal efficiency due to using the intercooled cycle in place of the plain cycle is best illustrated by a representative example, in which the overall pressure ratio is 14, the compressor efficiency being 0·85 and the turbine efficiency 0·90. The change in efficiency is investigated for a range of temperatures from 850 deg. K. to 2,200 deg. K. The intercooled cycle does not produce positive

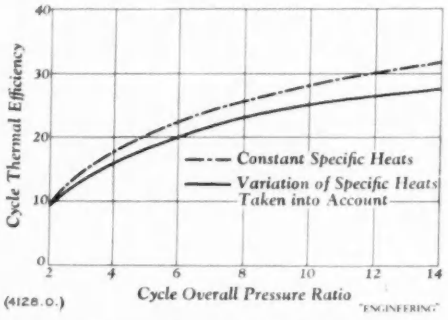

Fig. 16 Values of thermal efficiency in terms of pressure ratio at which thermal efficiencies of plain and intercooled cycles are equal.

work for maximum temperatures below about 620 deg. K., while the plain cycle requires 770 deg. K. for positive output. Variation of specific heats is taken into account. The results are presented in graphical form in Fig. 17, from which it is clear that in the narrow range of temperatures between 770 deg. K. and 920 deg. K. the intercooled cycle has the better efficiency. The slope of the curve representing percentage efficiency change is very steep in this narrow temperature range, the gain falling from 20 per cent. at 850 deg. K. to 5 per cent. at 890 deg. K.

Between 920 deg. K., where the efficiencies are equal at 27 per cent., and about 1,200 deg. K., the percentage improvement in efficiency with the *plain* cycle rises steadily to a maximum of nearly 7 per cent., but at higher temperatures tends to fall almost linearly to about 4 per cent. at 2,200 deg. K. Comparative values of efficiency at this temperature are, for the plain cycle 40·6 per cent., and for the intercooled cycle, 39·0 per cent. Over a very wide range of temperatures the plain cycle therefore has clearly the better efficiency.

Fig. 17 also shows the percentage gain in power output from the intercooled cycle. With increasing maximum temperature the gain falls rapidly from over 100 per cent. at 920 deg. K. to only 10 per cent. at 2,200 deg. K. Thus ultimately there is little to choose between the performance of the two cycles, and this is seen to be true in the general case as T_3 becomes very large, by comparison of (1) with (3), and (2) with (4). The efficiency of the intercooled cycle could be raised above that of the plain cycle by the inclusion of a heat exchanger. But if the main purpose of high-temperature operation is the improvement of efficiency rather than output, this can be achieved by a heat exchanger alone. Increased specific output is, of course, also obtained by raising the maximum temperature of any operating cycle; in the preceding article it is estimated that in a relatively simple arrangement of compressors, combustion chamber and turbines, involving only a heat exchanger, the output could be increased from 150 to more than 300 b.h.p. per lb. of air per second by raising the maximum temperature from 1,400 deg. K. to 2,000 deg. K. Such considerations would seem to rule out the use of intercooled cycles at the highest operating temperatures.

Acknowledgment and References

The author is indebted to Professor A. F. Burstall, D.Sc., Ph.D., M.I.Mech.E., for his advice and encouragement in the preparation of this and the preceding article.

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POST-WAR POWER STATIONS

ECONOMICAL AND TECHNICAL TRENDS

A paper, "The Post-War Trend of Power Station Plant Design," was read by Mr. F. J. Hutchinson before the Manchester Association of Engineers on February 8. In dealing with the progress which was being made he reviewed the history of the electricity supply industry, and the relevant industrial applications which had been assayed, in order to trace the growth and root cause of the generating plant pattern as it appeared at the beginning of 1957. In doing this he gave brief descriptions of the Severn Barrage and Pimlico District Heating schemes, and mentioned the developments which had taken place in the use of water power, of peat and coal slurry and of process steam in connection with industrial generating plant.

Dealing with the development of large power stations for the supply industry since the war, he said that the main consideration had been capital cost. This was apparent from Fig. 2, which showed that the price per kilowatt of plant installed had increased from less than £20 in 1930 to about £60 in 1954. There was a tendency for this to settle down at £50 per kilowatt at present day prices, and this had been achieved by installing large blocks of power produced by large machines in one place.

From 1925 to 1935 the practice in the joint design of the boiler house and turbine rooms had been to instal six boilers per turbo-alternator. During the next five years five boilers per two turbo-alternators were common and from 1945 to 1950 seven boilers for four turbo-alternators. From 1950 to date it had been usual to provide one boiler per turbo-alternator, the latter being disconnected on the steam side from adjacent sets. There had therefore been a progressive policy of decreasing the spare boiler in relation to the turbo-alternator until the unit arrangement was reached as indicated in Fig. 1.

The major reason for this was the general introduction of pulverised-fuel instead of chain grate-stoker firing. For when a stoker was being maintained its boiler was out of commission, while the installation of a spare pulverising group enabled servicing to be carried out with the boiler steaming at full load. Other reasons were that more suitable metals had been produced for the onerous conditions which had to be met, the improved design of furnaces and superheaters and the ever increasing cost of coal. In a modern boiler little improvement was to be expected in efficiency since the main loss, which amounted to about 9 per cent., was due to the temperature of the flue gas ejected to the atmosphere. This temperature was not usually much below 300 deg. F. owing to the relatively high dew point of the gases produced by burning the bituminous coal predominantly found in this country.

IMPROVEMENTS IN THERMAL EFFICIENCY

Fig. 2 showed also the increase in the combined heat rate of the boiler house and turbine house, better known as the station thermal efficiency, which had taken place over the last 30 years. This had been increasing steadily. A very high thermal efficiency with low reliability and excessive maintenance was, however, not commercially economic. The only thermal efficiency figure therefore which was of value was that which was obtained over a year's working with a high availability factor. The maximum efficiency to

date in this country was 31·46 per cent. with an availability of 88 per cent. This had been achieved at the Portobello station, near Edinburgh, while in America the figure of 34·5 per cent. had been reached at the Kyger Creek station.

A rewarding method of cutting down the capital cost of a station was by decreasing the cost of the building, which had risen from 2*s.* 6*d.* to over 7*s* per cub. ft. during the last 20 years. In 1953 the average volume of main building per kilowatt of installed plant had been 55 cub. ft., but the Americans claimed to have reduced this to about 15 cub. ft. by installing the boilers and turbines partially or wholly in the open.

BOILER DESIGN

The boilers themselves had undergone a dramatic change in structure, rating and size. For reasons of economy they were now integrated with the boiler house steelwork and were suspended from the roof. Boilers now under construction in this country had ratings from 540,000, 860,000 to 1,350,000 lb. per hour and it was believed that ratings up to, say, 2,200,000 lb. per hour were being investigated. The advent of pulverised fuel and the radiant heat which was thereby made available not only for the steam generating tubes but also for some portions of the superheater, had led to a great increase in the height of the furnace and the replacement of a wide squat shape by a slim, elegant structure.

Normal chain-grate stoker-fired boilers were satisfactory up to outputs of 150,000 to 200,000 lb. per hour, after which other methods were generally adopted. These included the "spreader stoker," which could be successfully operated in conjunction with boilers up to 250,000 lb. capacity, while in addition to the pulverised fuel furnace the Cyclone furnace had been developed for large boiler units. This furnace was particularly successful in burning coal with an ash fusion temperature of about 2,200 deg. F. or less. Boilers with outputs of 1,000,000 lb. per hour were being successfully operated in America when equipped with three or four such furnaces and it was believed that units with similar furnaces with outputs of 860,000 lb. per hour were projected in this country.

It was improbable that slag-tap furnaces would make much headway in Great Britain as the ash fusion temperature of the coal used was an important factor in their employment: British stations had to take any coal that might be delivered.

Pressurised furnaces, which were entirely under the influence of the forced draught fans, had not been developed in this country, although it was claimed that they were 0·5 per cent. more efficient than the more conventional types. Practically all large modern boilers were associated with re-heat turbines, and in their design arrangements were made to receive steam which had already passed through the high pressure end of the turbine and required re-heating in the gas circuit.

A MAJOR PROBLEM

The major problem in connection with steam pipes was metallurgical. Up to 1,050 deg. a ferritic steel to which molybdenum and vanadium had been added could be used, but above that figure it was necessary to use austenitic steel. In turbines the continuous maintenance of very small clearances between the fixed and moving blades was necessary. Manufacturers had therefore been providing high-pressure high-temperature forgings and castings of chrome-molybdenum steel. This might be replaced by austenitic steel as the steam pressure and temperature were increased further. The difficulty experienced in the welding of austenitic steel tubes had been overcome by performing the operation in an atmosphere of helium on the outside and argon on the inside of the tube.

The high-pressure ends of very-high-pressure high-temperature turbines were steam-cooled by providing the normal casing which held the stationary blades or diaphragms with an outer casing, and circulating cooler steam drawn from a lower stage in the space so formed. This restricted temperature fluctuations in that part of the casing which was required to retain its definite location in regard to the moving blades. Re-heating ensured that steam of not more than 13 per cent. moisture content reached the last few blades, the maximum tip speed of which in this country was about 1,275 ft. per second. Some American designs were allowing speeds as high as 1,450 ft. per second.

The supply of steam to the high-pressure and low-pressure feed water heaters from appropriate stages of the turbine ensured that only sufficient steam reached the exhaust to enable the leaving losses to be economically justified. These feed water heaters, however, considerably complicated the arrangements for the boiler feed pumps. For 120 MW sets and above, split feed pumps were used in this country, low pressure pumps delivering the feed through the water heads of the high pressure heaters to the suctions of the boiler feed pumps. The temperature of the water thus handled might be as high as 435 deg. F. In America the large majority of the feed pumps were in one unit, and delivered the water at full pressure through the water heads of the high pressure heaters to the boilers. It was anticipated that the operating difficulties with the split pump method would be considerable.

ALTERNATOR CHANGES

At the alternator end the greatest change to date had been hydrogen cooling which, with a gas pressure of 15 lb. per sq. in., enabled an increase in output of 19 per cent. to be obtained against a standard temperature rise of 50 deg. C. A pressure of 30 lb. per sq. in. had been incorporated in new designs. The cooling of the copper bars in the stator and rotor slots had been the subject of considerable experimentation. The latest designs employed hollow bars through which hydrogen was forced, thereby removing the heat by direct contact. At least one manufacturer had produced an alternator in which the stator bars were cooled by distilled water, which was forced through their longitudinal centres (ENGINEERING, vol. 182, page 781, 1956).

Undoubtedly the most spectacular event in the last few years was the progress which had been made in the designs of generating stations for which the steam is to be provided by nuclear reactors in conjunction with heat exchangers.

In general, it might be stated that the graphite-moderated gas-cooled reactor would probably not be superseded by any other type in the near future. One of its drawbacks was that it was not easily adaptable for small outputs as are required by industry, but experimentation was proceeding in many directions of which those relating to the pressurised water reactor and the boiling water reactor appeared to offer some promise for smaller outputs.

At the first British Nuclear Energy Conference held in November, 1955, it had been stated that by 1980 nuclear plant would be producing electrical energy equivalent to the consumption of 33 million tons of coal per annum. It was suggested that this was probably an understatement.

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The range of roller shutters manufactured by Golmet Limited, Virginia Park, Caerphilly, Glamorganshire, has now been increased by a door, the curtain of which is made from single steel sheets corrugated and riveted. The curtain runs in steel channels on nylon washers and is electro-zinc coated. Two standard sizes are being made, 7 ft. wide by 6 ft. 8 in. high, and 8 ft. wide also by 6 ft. 8 in. high.

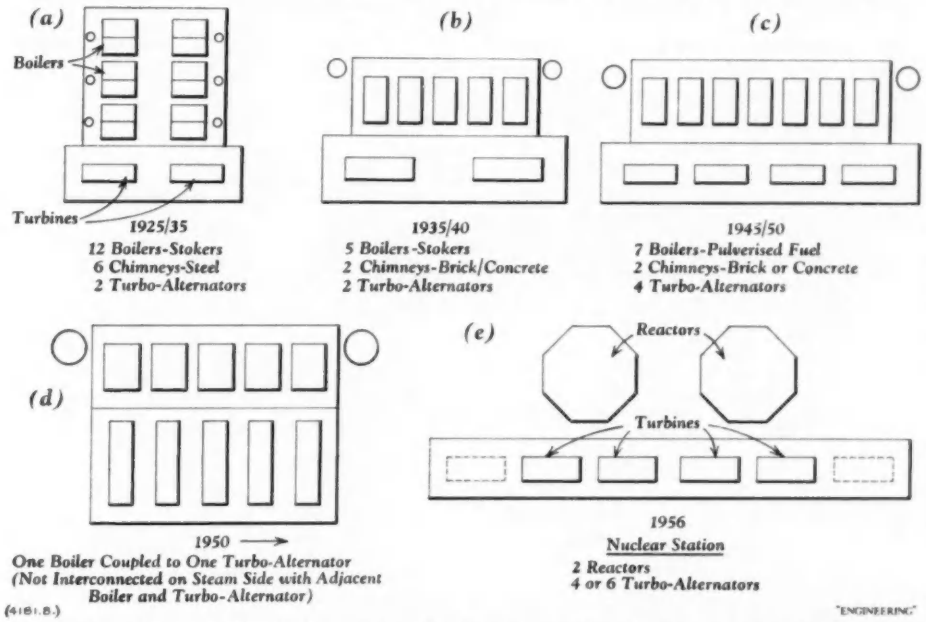


Fig. 1 Over the years, due to increased availability, the number of boilers to each turbo-alternator has been steadily reduced, reaching one to one before 1956. Nuclear stations reduce this still further to one to two or even three.

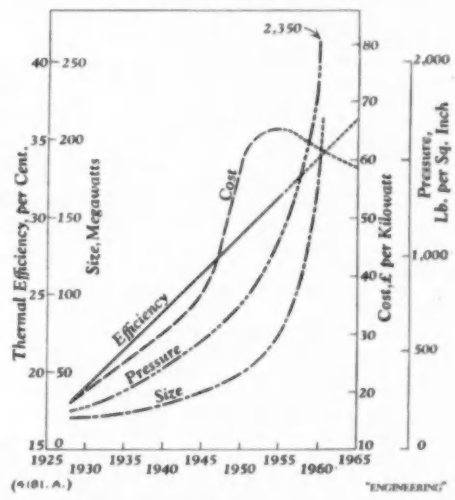
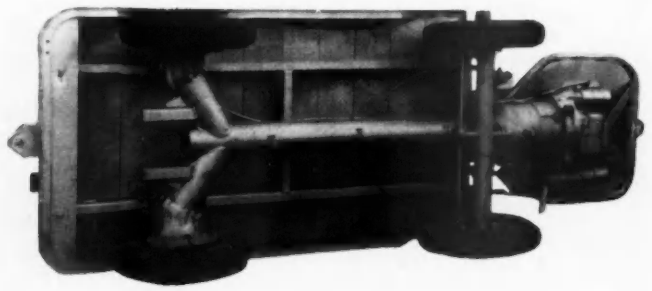


Fig. 2 The thermal efficiency of power stations has now reached 31·46 per cent. Costs are being reduced by less building.



Figs. 1 and 2 In the German " Hydrocar " the driver sits astride the engine which powers the hydraulic pump of the infinitely variable transmission unit. Full travel of one of the levers will change the speed from full forward to full reverse. The second lever controls steering and the third is the parking brake. The tubular Y-chassis acts as an oil reservoir and cooler; the transmission pipes run within it.

INDUSTRIAL TRUCK WITH HYDRAULIC TRANSMISSION

A two-ton industrial truck has been developed by Güldner-Motoren-Werke, Aschaffenburg, Germany, which has an infinitely-variable hydraulic transmission driven from a single-cylinder Diesel engine. The " Hydrocar " has a tubular backbone chassis in the form of a Y with the engine and axial-piston pump carried on the front end and independent hydraulic motors on the two forked members which form the rear axle, one driving each rear wheel. Pipes housed inside the tubular chassis comprise the outward and return circuits to the two motors which are connected in parallel and are self-compensating for differential functioning. The truck itself is shown in Fig. 1 and the chassis in Fig. 2.

The pump is basically of the swash plate type, having a ring of cylinders lying parallel to the axis, the pistons being operated by ball jointed rods. Assuming constant engine speed, the pump output (and therefore transmission ratio and vehicle speed) is determined by the angle of tilt of the circular pump body. Pump body and driving plate rotate together, and when their faces are parallel there is no axial piston movement and therefore no output. Piston displacement starts when the pump body is tilted relative to the driving plate, and the rate of oil flow is proportional to the angle of tilt. The motors are constructed similarly to the pump, except that the cylinder block and driven plate are rigidly positioned at an angle of 30 degrees. As with the pump, block and plate rotate in unison. The latter is on a shaft terminating in the pinion of the final drive reduction gearing. The pump is shown in section in Fig. 3 and one of the motors, together with the final reduction gearing to the road wheel, in Fig. 4.

To dissipate frictional heat generated by the moving fluid, the entire hollow chassis serves as an oil storage tank for cooling. Its capacity is 40 litres. A bar magnet inserted through the casing into the oil attracts metal particles that would otherwise accelerate wear of precision moving parts. It is intended to be withdrawn and cleaned at regular intervals.

A submerged gear-pump, driven from the input shaft of the piston pump, constantly draws in oil from the reservoir and forces it under high pressure through a ball valve into the intake side of the piston pump and thence to the transmission circuit. At the same time, surplus oil is bled back to the tank through a spring-loaded release valve in a branch pipe loop shunted across the main circuit between the two motors. A small built-in safety valve protects the main pump against high-pressure overloads.

The driving motors are reversed by tilting the pump body in the opposite direction to normal, causing a reversal of the oil flow. To enable the gear pump to deliver automatically into the input or low-pressure side of the main pump, there are two feed galleries with ball valves that switch the flow according to the back pressure of the circulating oil. Since the drive is hydrostatic, braking is effected merely by placing the pump body in the neutral position, when oil delivery stops and the motors are blocked. When stationary, the vehicle cannot normally be pushed, since the wheel motors would then act as pumps working against each other. In order to relieve this counter-acting pressure when desired, there is a hand valve in the branch loop which is used to isolate the input from the output pipe temporarily and permit free rotation of the motors.

A single lever linked to the pump tilt mechanism controls speed in both directions as well as braking. A twist grip operates the engine throttle. The front beam axle is centrally pivoted on the tubular spine like a tractor, and steering is controlled by a second hand lever. There is a mechanical parking hand-brake working on the front wheels. The driver sits astride the engine cover on a saddle which is long enough to enable him to face either way.

The air-cooled 4-stroke Diesel with 439 c.c. displacement has a bore of 75 mm. and a stroke of 100 mm., with a 19 to 1 compression ratio. Direct injection is used. Output is 6 b.h.p. at 2,200 r.p.m. Unladen weight of the Hydrocar is 900 kg., overall length 3,200 mm. (10·5 ft.) and width 1,240 mm. (4 ft.). The 1,200 mm. by 2,200 mm. platform is suspended on four coil springs. Maximum speed is 15 k.p.h. (9·4 m.p.h.) in either direction, and drawbar pull 20 tons.

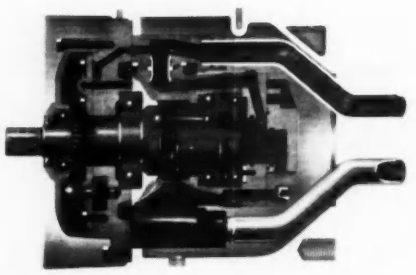


Fig. 3 The output of the hydraulic pump, and therefore the vehicle speed, is controlled by varying the relative angle of tilt between the pump body and the driving plate.

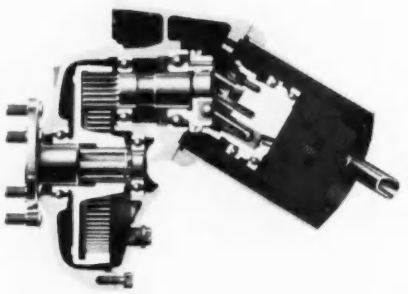


Fig. 4 The hydraulic motors follow the same design as the pump but their angle of tilt is fixed. They drive the road wheels through an internal reduction gear.

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ELECTRIC MOTORS WITH CLASS E INSULATION

Higher Temperature Rise and Greater Compactness

A new range of three-phase axially ventilated squirrel-cage electric motors with outputs ranging from ½ to 50 h.p. has been introduced by the English Electric Company, Limited, Kingsway, London, W.C.2. Their most important feature is that full advantage has been taken in their construction of the properties of insulation of the Class E type. This allows a temperature rise of 65 deg. C. with an ambient temperature of 40 deg. C. to be used giving a maximum stator winding temperature of 105 deg. C., although the temperature of the frame will not normally exceed 90 deg. C. in free air. The advantage of this increase in temperature rise from the present 40 deg. C. is that a greater horse-power can be obtained from a given size of frame and consequently a smaller, lighter and cheaper machine can be produced.

A further important feature of the new motors is that their fixing dimensions comply with the new British Standards draft specification CW(ELE) 6246 and, except for the two smaller frames, for motors with outputs up to 2 h.p., these dimensions are similar to the American National Electrical Manufacturers Association Standard MGI-1955. For a given frame size, however, the outputs and therefore the shaft diameters have been increased in accordance with the provisions for Class E insulation.

This new range of motors, which is known as Class C, is at present available only as foot-mounting machines, although others with flange and skirt mounting will shortly be produced. As is seen from the illustration, showing one of the series, they have a smooth contour, the frame and end shields being of cast iron, which are accurately machined to ensure concentricity

and alignment. The stator windings are formed from polyvinylformal-covered wire and are impregnated in an automatic continuous plant which immerses them endwise, thereby ensuring the penetration of the varnish along their entire length and excluding air pockets. The completed unit is therefore highly resistant to moisture. The pear-shaped slots are lined with waterproofed linen and winding is effected before the stator core is inserted in the frame, thus allowing greater accessibility.

The shaft is of 0·4 per cent. carbon steel with an ultimate tensile strength of 38 to 42 tons per sq. in., and carries a rotor consisting of insulated laminations with die-cast conductors of 98 per cent. aluminium. The end rings are also die-cast. All the rotors are balanced in an electronic machine to fine limits. The cast-iron end shields have four bolt fixings and can be turned to any of four positions at angles of 90 deg. The terminal box can also be turned to any one of four positions at right angles to each other to facilitate cable entry. This box is normally fitted on the right-hand side of the motor when looking towards the tail end, but by removing the end shields and rotor and reversing the stator frame it can be positioned on the opposite side.

Ventilation is obtained from an axial fan which draws air from the driving end and expels it at the tail end.

One of a range of axially ventilated motors built to British Standard Specification CW(ELE) 6246, with Class E insulation.

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SAFETY SLINGS

No Damage to Fragile Goods

The handling of goods on a crane has always presented a risk of damage to fragile components by the slings used for the purpose. To avoid any risk of damage, Cable Covers Limited, St. Stephen's House, Westminster, London, S.W.1, have developed the "Talurite" safety sling, in which the actual load is carried on pads of tough rubber. An example of a six-strand sling using the patent Talurite shackle was recently sent to us. The wires of the sling are threaded through rubber blocks, a pair of wires to each block, so that not only is the load taken by the rubber, but the wires are kept at their correct spacing. In this way bunching or straggling of the elements of the sling is avoided. Another point is that while the sling remains completely flexible it cannot kink when rolled after use, and so suffer damage itself. Slings can be made to almost any size, both as regards length and load carrying capacity; as an example, a small two-strand sling having stranded wires some $\frac{3}{16}$ in. in diameter, and rubber blocks measuring $1\frac{1}{2}$ in. by $1\frac{1}{4}$ in. would carry a load of half a ton. A sling made of 10 wires of $2\frac{1}{4}$ in. circumference would be capable of handling 42 tons, but this is by no means the limit of capacity that can be handled by slings of larger size.

MEASURING LOW OIL FLOWS

For accurate and dependable measurement of low oil flows, George Kent, Limited, Luton, Bedfordshire, have recently introduced the CM oil meter, which is of the semi-positive rotary-piston type, for flows up to 200 gallons per hour, and for installation in pipe-lines of between $\frac{3}{8}$ in. and $\frac{1}{2}$ in. bore. An important application is for recording the fuel consumption of the small oil-fired furnaces that are increasingly being used in industry and commerce.

The new meter is of compact design and simple construction, and all parts, which are manufactured from corrosion-resistant materials, are easily replaceable in the event of excessive wear or accidental damage.

In the semi-positive rotary-piston type of meter, the flow, entering through a shaped inlet port, continuously drives a piston in an eccentric path around an accurately machined measuring chamber, each revolution representing a given volume of liquid passed through the meter. The rotary movement of the piston is employed to open and close alternately the inlet and outlet ports of the measuring chamber as well as to drive the counter mechanism of the meter. The advantage of this type of meter is its ability to register accurately very low flow-rates while still retaining excellent high-flow performance.

The CM is built up of five main components: the meter body, the measuring chamber, the under-gear, the counter and the counter box. The measuring chamber and the undergear are both completely self-contained units and may be removed as such from the brass meter body into which they are both fitted. The measuring chamber and its top plate are machined from high-grade brass stampings; the piston is made of anodised aluminium and the other measuring-chamber parts are of either gun-metal or nickel. A nickel pinion, projecting from the top of the measuring chamber, engages with the first gear of the under or reduction-gear train. The nickel gear wheels and spindles all run in oil-retaining sintered-bronze bearing bushes pressed into the top or joint-plate and bottom plate of the under-gear. A pinion, on a spindle passing through a high-pressure gland in the joint-plate, drives the cyclometer-type straight-reading counter. The counter box, a brass stamping, contains the counter mechanism and clamps the undergear in position, an oil-resisting gasket making a pressure-tight joint between the under-gear and the counter. Five tin-base-alloy counter number-

The CM low-flow oil meter measures oil flows of from 1·5 gallons to 200 gallons per hour with an accuracy of ± 2 per cent.

rollers, with white figures on a black background, register the amount of oil which passes through the meter. A short-sweep pointer, working in conjunction with a circular scale on the dial, is provided for indicating small or fractional quantities. The dial is of vitreous-enamelled copper with clear, permanent markings which ensure lasting legibility. An arrow cast on the side of the body indicates the correct direction of flow of oil through the CM. Sealing holes and lugs are provided to prevent unauthorised interference with the meter. The CM may be calibrated in either gallons or metric units, and the counter has a maximum registration of either 1 million gallons or 10,000 cub. m. The net weight of the meter, including adaptors, is about $5\frac{1}{4}$ lb. The maximum working pressure is 100 lb. per sq. in., and the maximum working temperature 200 deg. F.

The performance of the meter is given below:

For viscosities at operating temperature from 25 to 80 seconds Redwood No. 1

Starts to register..	At 0·5 gal./hour
Range for accuracy of ± 2 per cent.	3 to 200 gal./hour
Head loss ..	7 ft. of liquid at 200 gal./hour

For viscosities at operating temperature of 80 seconds Redwood No. 1 upwards

Starts to register ..	At 0·25 gal./hour
Range for accuracy of ± 2 per cent.	1·5 to 200 gal./hour
Head loss ..	9 ft. of liquid at 200 gal./hour at viscosity above, increasing to approx. 15 ft. at viscosity of 200s Redwood No. 1.

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LIGHT COLLAPSIBLE CONTAINERS

Packing is a problem that has to be faced by almost every industry. Many types of container are on the market, and several are collapsible for return. One that is both collapsible and returnable is the Tracon, available from Tracons Limited, Mowden Hall, Darlington, and made of a light alloy. A special feature is that there are no loose parts to be lost. The ends and sides are hinged to the bottom and the lid is fixed by swing links to one side. All the corners are protected by steel plates. When assembled, the lid is clamped by toggle clips, which are also used to hold the whole together when collapsed. Four sizes are available ranging from 24 in. by 12 in. by 12 in. to 50 in. by 24 in. by 24 in.

CARGO LINER WITH UNPAINTED ALUMINIUM SUPERSTRUCTURE

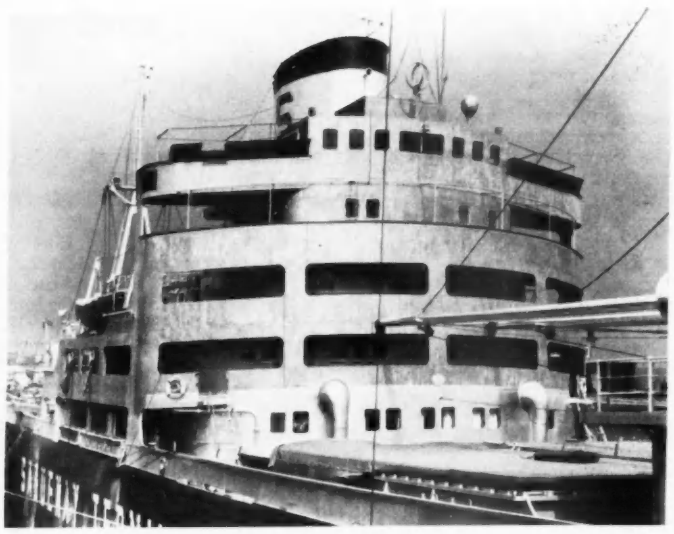
The visit to this country recently of the Canadian single-screw cargo liner S.S. Sunrip provided an opportunity for the inspection of a vessel having several unusual features. The Sunrip, which called at Avonmouth with a cargo of grain, is a ship of 12,825 tons deadweight carrying capacity, built by Davie Shipbuilding Limited, Lauzon, Quebec, owned by the Sun Steamship Company and operated by Saguenay Terminals, Limited, Montreal, the shipping subsidiary company of the Aluminium Limited Group. The Northern Aluminium Company Limited, in this country, is the chief fabricating subsidiary company of the Aluminium Limited Group. The Sunrip is registered in London, and, as we gave an illustrated description of the ship on page 503 of our issue of June 15, 1956 (vol. 181), perhaps it will be sufficient to recall that she has a length, between perpendiculars, of 450 ft., a breadth moulded of 62 ft. 6 in., a depth to the upper deck of 40 ft. 8 in., and a draught of 29 ft. 2¾ in. The vessel is propelled by geared steam turbines. She is designed primarily for the bulk transport of alumina, or purified bauxite, from Kingston, Jamaica, via the Panama Canal, to Kitimat, British Columbia. Provision, however, has also been made for the carriage of grain and general cargo.

The most interesting and noticeable feature of the Sunrip is her entirely unpainted all-welded aluminium-magnesium alloy midship superstructure, seen in the accompanying illustration. The superstructure has a height of 39 ft. 6 in., a length of 80 ft., and a width, at the upper deck, of 62 ft. The aluminium-alloy structure commences above the upper deck where it is riveted to steel coamings extending above the deck. The height of these coamings varies, their principal purpose being to place the joint between the two dissimilar metals high above any point where sea water might collect. The house sides are connected to a steel coaming 3 ft. 6 in. above the deck, but the aluminium-painted steel has been extended to just above the bridge deck on the house front, as may be seen in the illustration. The surface of the aluminium was finished by the ship's builders by scratch brushing, using rotary brushes made of crimped stainless-steel bristles fitted into electric and air-powered tools.

The vessel has been in service since the end of 1954, and during that time the only surface treatment for the bare aluminium plating has been occasional washing with a soap solution and bristle brooms. As will be evident from the illustration, the aluminium surface presents a uniform matt appearance on which the marks left by the scratch-brushing treatment may still be plainly seen. In fact, the present excellent condition of the metal suggests that no painting will be required in the foreseeable future—a situation which means a clear saving in maintenance costs.

In addition to the metal in her superstructure, aluminium alloys have also been chosen for the ship's funnel, lifeboats, davits, after deckhouse, hatch beams and boards, piping, ventilation trunking, windows, and such miscellaneous items as ladders, awning supports, guard rails, engine-room flooring and gratings and the refrigerator gratings; over 120 tons of aluminium alloys were incorporated in the Sunrip's construction, representing a saving in weight of upwards of 195 tons.

This saving in weight, brought about by the adoption of light alloys, was naturally a major factor in the decision to use these materials and, at the time the ship went into service, it was estaimated that, on her regular run from Jamaica to British Columbia, the extra cost of the aluminium would be paid for in eight years. The gain in deadweight tonnage is expected thereafter to produce substantial extra income.



The unpainted all-welded aluminium-alloy superstructure of the S.S. "Sunrip," a 12,825 ton deadweight Canadian cargo liner carrying aluminium ore. Only 120 tons of light alloys were used for midship houses, funnel, after deckhouse, hatch beams and boards, lifeboats and piping.

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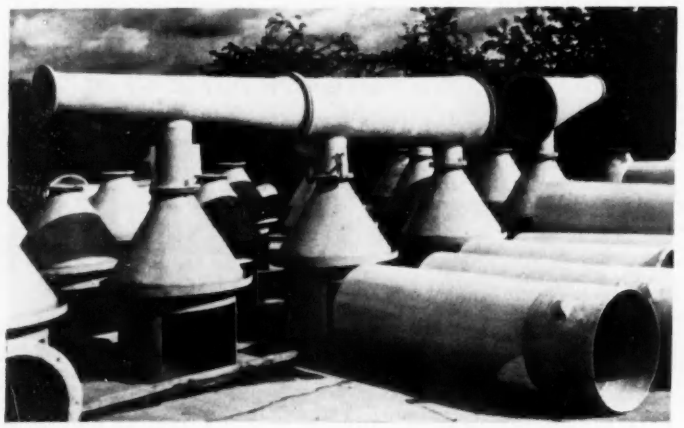
RESIN AND GLASS FIBRE LAMINATES

A wide range of chemical apparatus and plant is now being fabricated by Mendip (Chemical Engineering) Limited, Feltham-road, Ashford, Middlesex, from compound laminates made from Bakelite Limited epoxide and polyester resins reinforced with glass-fibre materials. The new laminates offer several advantages compared with conventional materials employed in the construction of chemical plant, and one of their outstanding features is their excellent chemical resistance, which enables them to be used for a variety of purposes. Other properties, such as abrasion resistance, can be heightened if required to meet particular conditions. In addition, the high strength to weight ratio of the laminates means that structures made from them are light in comparison with some other materials available. Hence less effort is required during installation. Finally, the use of these compound laminates provides considerable freedom of design and enables structures of complex shape to be produced readily.

The accompanying illustration (below) shows compound-laminate ducting, cowls and stacks, which form part of the fume-extraction system installed recently at a preserve factory.



Ducting, cowls and stacks forming part of a fume-extraction system at a preserve factory, fabricated from compound laminates of polyester and epoxide resins reinforced with glass-fibre materials.

SHOCK FORMING

There have been many developments in the techniques used in metal forming, but the fundamentals have really remained unaltered. Now, it seems, far-reaching changes are likely, if a new method developed by the Lockheed Aircraft Corporation in America comes into general use. By using explosive charges instead of conventional methods of piercing or forming metal, Lockheed have succeeded in dealing with materials which would otherwise be virtually impossible to work, and have done so without causing the work-hardening cracks which might seem inevitable. The method depends on the principle that if a forming tool travels faster than sound it precedes the shock wave which causes work-hardening.

Lockheed have put explosive charges to work in place of normal press drawing, for piercing, and for expanding tubing in a die. For drawing work, high-explosive charges are detonated over the metal and the die. Stainless steels and other "difficult" metals have been drawn in this way beyond their theoretical limits. A cartridge-actuated stud-driver converted into a captive-piston punch has been used to pierce steel up to 112 tons tensile, and the punch, driven at 800 ft. per second, produces a clean hole with squared edges and free from radial cracks. Low-power charges have been applied to the expansion of tubing within a die, and pressures of over 50,000 lb. have been used; the pressure is only limited, in fact, by the strength of the die and firing mechanism.

Apart from its obvious applications in dealing with metals which would otherwise be unworkable, shock forming opens up a whole series of interesting prospects for the machine and press shops. It is difficult to see how there can be much development of the orthodox methods of metal working; perhaps the unorthodox will gain currency sooner than may be expected.

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LIGHTWEIGHT COUNTER

An electromagnetic counter weighing 1·1 oz. has been produced by Counting Instruments, Limited, Boreham Wood, Hertfordshire. It is claimed that the counter will not fail under severe mechanical shock: when subjected to accelerations 7*g* an accurate count was still maintained. The energising voltage is from 22 to 24 volts direct-current and it will operate on 10 milli-second pulses at a maximum rate of 37 per second. A series of moulded number wheels give a display from 0000 to 9999.

ATOMIC REVIEW

Means to Many Ends

Preoccupation with the power-producing aspect of nuclear reactors has tended to obscure their versatility. They may, for example, be used as a source of process heat or even for domestic heating on a large scale; but they are particularly important as multi-purpose tools. Experimental and research reactors provide a variety of services; they may be used as small-scale models of larger prototypes, as means of testing materials and components, or as sources of radioactive isotopes or radiation. They are specially valuable as sources of that almost priceless commodity, the neutron, and their use in cancer therapy to supply direct radiation is already established. Britain has a considerable number of study reactors, either completed or building, at Harwell, for example, and Dounreay; others are to be built at the new establishment at Winfrith Heath, probably including a small prototype of the very high temperature (VHT) system. There is also the private research reactor, MERLIN, which the A.E.I.—John Thompson Nuclear Energy Company are successfully marketing. It was described in ENGINEERING on page 220 of our issue of April 13, 1956. Some recent news of research and test reactors in the United States is published below.

National Reactor Testing Station

Several new reactors are now nearing completion and others planned at the United States Atomic Energy Commission National Reactor Testing Station at Arco, in western Idaho. Arco is said to be the first town in the world ever to have been lighted by power from a nuclear reactor.

Engineering Experiments.—Soon to be completed at N.R.T.S. is an engineering test reactor (ETR) for testing reactor component parts.

Boiling and Excursions.—The first special power excursion reactor test facility (SPERT-1), which is illustrated in Fig. 1, recently received its final inspection and has now been put into operation. It is one of several boiling-water reactors built and tested at the station to develop a plant with a high degree of safety. In more than 200 tests, this reactor has demonstrated temperature self-regulation characteristics which may serve as a basis for assessing reactor hazards. Two additional reactors of similar type (SPERT-2 and 3) are being designed, and central control facilities are already being built for them. To extend the work on boiling-water reactors begun with BORAX and EBWR (recently stated in Atomic Review to have begun operation), the A.E.C. are to build at N.R.T.S. a new research facility costing 8½ million dols. To be known as ARBOR (Argonne boiling reactor facility), it will comprise core, pressure vessel, condensers, heat exchangers, pumps and auxiliary equipment designed to allow the simulation of a wide range of operating conditions.

Propulsion and Power Research.—Atomics International, a division of North American Aviation are constructing at the station an organic-moderated reactor experiment (OMRE) with a design heat rating of 15 MW. Other plants include a gas-cooled reactor experiment (GCRE) for tests in the development of package power reactors and small central stations, a prototype for a large ship reactor, and new test facilities for aircraft studies. There will also be a low power reactor (ALPR) designed by the A.E.C.'s Argonne National Laboratory.

Breeders.—The station is also to have an experimental breeder reactor (EBR-2), and since 1955 has been operating a zero power fast critical assembly (ZPR-3), shown in Fig. 2, to obtain information for the larger plant. The breeder reactor is expected to produce 15 MW or more of electricity.

Zero Power Reactors

Unlike many other power producing plants, a reactor can operate at extremely low power with the same behaviour and operating characteristics as it would have at much higher powers. Consequently much data for full-scale reactors may be obtained from a comparatively inexpensive and convenient zero power reactor, in which fuel and control rod arrangements can be rapidly changed.

At the Argonne National Laboratory five zero power reactors have been built and operated; one of these is described in greater detail below. The first, ZPR-1, was started up on October 4, 1950, and was used to determine the final core design specifications for the reactor installed in the submarine Nautilus. The second, ZPR-2, was a prototype of the large plutonium producing reactors designed by Argonne and Du Pont Company specialists for the Savannah River plant. ZPR-3, referred to above, is a fast reactor built and operated by Argonne at the Idaho station. The fourth, ZPR-4, was a small reactor, serving as a neutron source, built at the Laboratory's site in Du Page County, Illinois. With the exception of ZPR-3 and 5, the work on all these experimental reactors has been completed and the assemblies dismantled to provide space for more advanced studies.

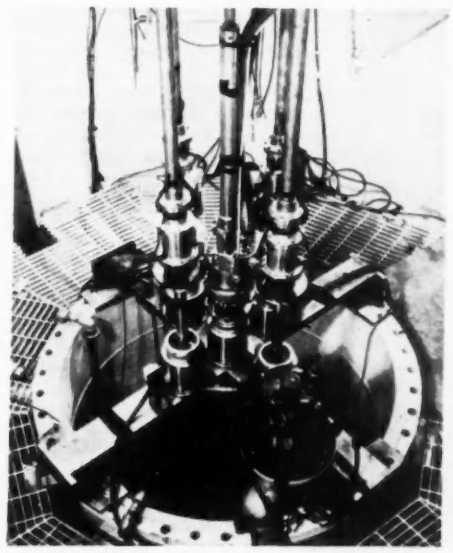

Fig. 1 An American experimental boiling-water reactor designed to provide data on reactor safety has recently begun operation. The reactor, SPERT-1 (special power excursion reactor test facility No. 1), is shown with outer control rods withdrawn. The centre rod gives fine control.

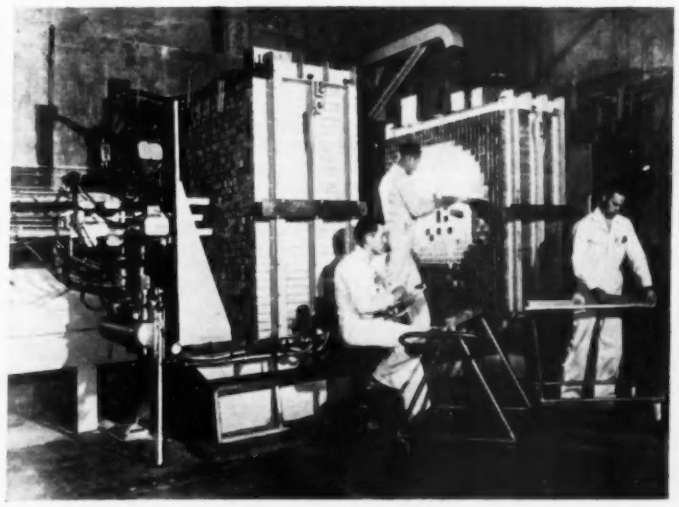

Fig. 2 Fissile material and other metals are loaded in trays located in the two halves of the United States zero power reactor, ZPR-3. Criticality is obtained by bringing the two halves together.

Fast and Thermal Reactor

Further details are available concerning the "fast-slow reactor" (ZPR-5) referred to in Atomic Review on February 1. The system was discussed at a recent meeting of the American Nuclear Society in Washington. This two-region critical assembly at the Argonne National Laboratory was started up last August 30 and comprises a 5 ft. diameter steel tank, in the centre of which is a fast core of 2 ft. square section containing 49 enriched-uranium fuel assemblies. Surrounding the fast core is a thermal reactor of natural and enriched fuel elements immersed in light water. The coupled system is said to combine the kinetics of a thermal reactor with, it is hoped, the breeding properties of a fast reactor. Thus it has the safety and ease of control of the former and the superior nuclear properties of the latter. It should require a much lower fuel inventory than a simple fast reactor and neutron economy is high. The nuclear reaction is started in the slow or thermal section and neutrons pass through the steel wall into the fast reactor section. The critical masses are so arranged that a chain reaction cannot be established or maintained in the fast section without neutrons from the thermal section. Thus control is effected simply by means of cadmium or boron control plates in the thermal region. Though the present assembly is intended simply to permit the study of fast reactors without control difficulties, a design for a power breeder using the coupled principle has been described.

Mass Produced Reactors

The first of a new series of small research reactors, the AGN-201, produced by Aerojet-General Nucleonics of San Ramon, California, went critical last October with only 656 gm. uranium 235. The company has now received permission to build three further low-power reactors of similar design for sale to colleges, universities and other educational and research establishments. In addition, it is proposed to exhibit an AGN-201 reactor in the Philadelphia Convention Hall during the Atomic Exposition and Nuclear Congress to be held from March 11 to 15 and announced in Atomic Review on February 1. The reactor will be brought up to power some 10 times a day and will be used to irradiate samples of polythene, polystyrene and aluminium.

The low critical mass of this reactor results from the unusual core design. Particles of uranium oxide (UO_2), containing 20 per cent. enriched uranium, are dispersed in a moderator of radiation-stabilised polyethylene resin to form an effectively homogeneous solid core. An even smaller critical mass could have been achieved by using a beryllium oxide (BeO) reflector but, because of the health hazards and high cost associated with handling beryllium oxide, this design was rejected, and the cylindrical core, 10 in. in diameter by 10·5 in. high, surrounded instead by a graphite reflector 20 cm. thick. The overall size of the reactor is 6·5 ft. diameter by 9 ft. high.

Shielding, provided by 10 cm. lead and 55 cm.

water containing 3 per cent. HBO_2, is more than sufficient for normal operation at 100 milliwatts. At this power level, the thermal neutron flux is about 3×10^6 neutrons per sq. cm. per sec., but with additional shielding, the reactor can be operated at 5 watts, with a flux of $1{\cdot}5 \times 10^9$ neutrons per sq. cm. per sec. The reactor is thus intended for use in education, medical diagnosis and other applications where high thermal neutron fluxes are not essential. Its experimental facilities consist of a 1 in. diameter glory hole passing completely through the core, four 4 in. diameter access ports passing completely through the reflector, and a graphite thermal column.

Particular attention, the makers claim, has been paid to safety considerations. The fuel-type safety and control rods operate so that reactivity is increased as the rods are inserted, and actuation of the conventional shut-down system causes their rapid ejection. Safety mechanisms may be initiated by a power failure, an earthquake detector, water shield level and temperature detectors, a manual shut-down button, and the power level monitor. In addition, the core includes a thermal safety fuse which will heat faster than the core and melt at 100 deg. C., causing the two halves of the core to separate in the event of any accidental power surge.

The reactor costs 95,000 dols. excluding the uranium fuel for which transfer and rental

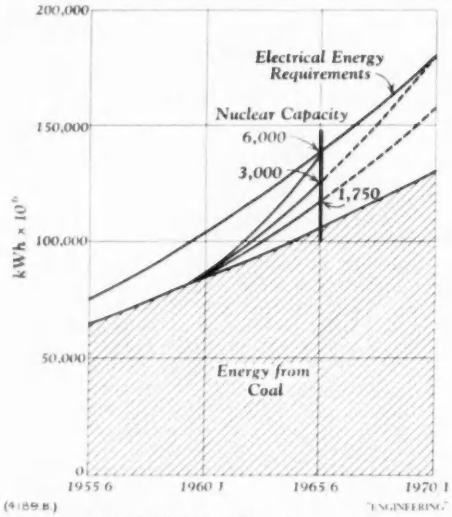

Fig. 3 Estimated electrical energy requirements and energy resources in the United Kingdom. The effect of various atomic energy programmes on the deficit are indicated.

charges have to be negotiated between the customer and the U.S.A.E.C. Aerojet-General Nucleonics hopes to instigate and maintain a production schedule of at least two reactors per month. The first has already been sold to the Naval Post-graduate School at Monterey.

Preliminary Pile Assembly

The Preliminary Pile Assembly (PPA) at the Knolls Atomic Power Laboratory is reported to have been started up and shut down 10,000 times in 8½ years. Operated by General Electric for the A.E.C., PPA is said to have yielded more data for a wider range of reactor systems than any other critical assembly. It can be shut-down and restarted in about 15 minutes, so allowing a great number of rearrangements of fuel elements in a given time. Operation is as follows.

A number of uranium-aluminium fuel discs (determined by calculation or experiment) are loaded into fuel-rod sub-assemblies, which are then inserted into two vertical matrices. The fuel rods also contain other discs simulating structural materials, coolant and moderator, and these are arranged in an appropriate geometrical pattern. Thus calculations for a variety of systems and combinations may be made. The two matrices (in some respects similar to the assembly illustrated in Fig. 2) are moved together by remote control and a chain reaction is initiated. Since operation is at very low power (about 1 watt), access for alterations and study is offered without serious radiation danger.

Self-Control

The self-controlling characteristic of a research reactor to shut down in the event of abnormal operating conditions has been demonstrated in tests on a 50 kW solution-type reactor conducted by Atomics International in the Santa Susannah mountains, California. Known as KEWB (kinetic experiment for water boiler reactors), the programme is being carried out for the A.E.C. The automatic shut-down is due to temperature increases and formation of gas bubbles in the reactor fuel which upset the neutron balance and terminate the reaction.

Research Reactor Projects

Announcements have recently been made concerning the United States research reactors listed in the table below. The table includes such details as the manufacturer, country to which the reactor is to be exported, the selected site and the purpose of the announcement, as—licence issued.

Reactor Patents

A number of United States Atomic Energy Commission patents have recently been published.

Water Corrosion.—The satisfactory operation of pressurised-water reactors is dependent on limiting the corrosive effect of water on the containing vessel. A proposed method of reducing the corrosion of iron and iron-based alloys, including steel, when these metals are subjected to the action of hot highly compressed water involves the addition of 50 to 400 c.c. of hydrogen gas per litre of water before the water comes into contact with the metal. (U.S. pat. 2,763,611: C. R. Breden.)

Fast Reactor Circulating System.—A liquid cooling system for a fast reactor has been designed to eliminate potential leak sources. A suitable liquid such as mercury is forced through the reactor under pressure of a gas, such as helium, which is inert to neutrons. The liquid cools the reactor, gives up its accumuleatd heat to a heat exchanger and is collected in a low pressure tank. The liquid is transferred from the low to a high pressure tank by electro-magnetic pumps, the output of which is regulated by a float in the high-pressure tank. Helium is maintained under high pressure in the high-pressure tank to cushion the pumping effect of the electromagnetic pumps and to cause and control the circulation of the mercury. This system is said to reduce radiation hazards due to leaks of dangerous coolants by eliminating accessories with gaskets and seals, such as mechanical pumps and valves, while providing positive circulation and control. (U.S. pat. 2,770,590: J. T. Serduke.)

Recent United States Research Reactor Announcements

Manufacturer or Designer	Type	Announcement	Receiving Country	Site or User	Purpose
AMF Atomics	10 kW swimming pool	Export licence issued	Netherlands	—	Isotopes and research
International G.E.C.	3 MW swimming pool	Ordered	Venezuela	Caracas	Isotopes and research
Babcock and Wilcox (U.S.A.)	5 MW swimming pool	Export licence issued	Brazil	Sao Paulo	Isotopes and research
Oak Ridge National Laboratory and AMF Atomics	5 MW swimming pool	Construction permit issued	—	Plainsboro, New Jersey	Bulk shielding
Argonne Laboratory and U.S. Air Force	Heavy-water moderated heterogeneous	Licence application	—	Bell Telephone Laboratories, New Jersey	Solid state materials studies
Westinghouse Electric Corporation	20 MW enriched uranium, light-water moderated	Permit granted but project abandoned	—	Nr. Pittsburgh, Pa.	Fuel element and radiation damage testing

Britain's Power Prospect

A survey of Britain's nuclear power prospects in the context of world atomic development was given in a lecture, " Nuclear Generation," delivered by Mr. P. J. Squire, system operation engineer of the Central Electricity Authority, at a recent meeting of the Association of Supervising Electrical Engineers. Some of his remarks are given in abridged form below. In addition, we conclude our summary of Sir Claude D. Gibb's Thomas Hawksley Lecture—" Some Engineering Problems in Connection with the Industrial Application of Nuclear Energy," referred to in Atomic Review last week.

Electricity Needs

What our energy deficit is likely to be and the size of nuclear programme necessary to meet

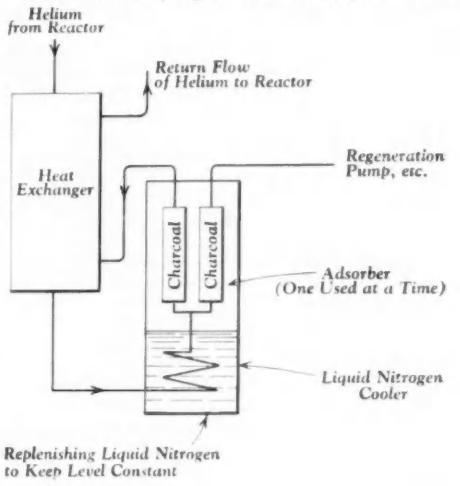

Fig. 4 Helium drier and adsorber made by British Oxygen Engineering for use in conjunction with the materials testing reactor DIDO.

it is indicated in Fig. 3. This diagram shows the present estimate of future electrical energy requirements up to 1970, together with the latest estimate of energy available from home-produced coal for electricity generation after other requirements have been met. The deficit, already apparent in 1955, must be expected to grow to 50,000 million kWh or 27½ per cent. of the annual requirements by 1970. To meet this about 8,000 MW of nuclear plant would be required, operating at high load factor. The deficit must be met in the early years by imported fuel, probably oil, and it must be mentioned that the transport of oil in very large tankers may well make oil a highly competitive fuel in this country in a few years time. Also plotted are the contributions which could be expected from three sizes of nuclear programme—first the 1955 White Paper programme, then programmes to give 3,000 MW and 6,000 MW by 1965. If the nuclear installation in 1970 were to be limited to that required to make good the coal shortage (that is, 8,000 MW) then clearly any programme aimed at much above 3,000 MW by 1965 would involve a change, after the first rapid rate of installation, to a slower rate, which would not be consistent with the best utilisation of our manufacturing resources.

Load Factor.—There is the prospect, however, that the later nuclear plants will have a lower

all-in cost of production when operated at high load factor than any of our coal burning plant. It may well therefore prove economical to generate at least the base load (that is, the continuous demand) on the supply system by nuclear plants. A limited capacity of conventional plant will undoubtedly have to run at night for system regulation and stability reasons. Allowing for this and making the bold assumption that the seasonal availability of nuclear plant will be similar to that of conventional plant, we arrive at a base load nuclear capacity of about 8,500 MW in 1970. This compares with the capacity of 8,000 MW which would be required in 1970 to meet our energy deficit. Anything above 8,000 MW would have to compete with conventional plant fired with home-produced coal. It seems probable that by then nuclear plants will do that if operated at high load factor and there seems good reason for aiming at least as high as 8,500 MW in 1970.

Since it is impossible for all the alternative coal-fired plant to be sited near the coalfields nuclear generation would probably be competitive at slightly lower load factors. Moreover there is some prospect of obtaining greater improvements in the system load factor than is assumed in this study (47 per cent. to 50 per cent.). The C.E.A. are fully conscious of the desirability of doing this and in most areas reduced night tariffs are now available. The surest way of increasing load factor, however, would be the wider adoption of shift working in industry but, although there is ample economic incentive for this, it seems doubtful whether the social problems involved could be overcome.

Pumped Storage.—The other obvious device would be the development of pumped-storage schemes. This does not appear attractive in competition with coal-fired plant at the present time, but would undoubtedly be so if the pumping unit required at night came from nuclear plant. Unfortunately the known potentialities for pumped storage in this country are comparatively small—a few thousand MW—and much of this would be so remote from centres of load that costly transmission would be necessary to make use of it. Nevertheless it could make a useful contribution by 1970 and a reasonably optimistic nuclear programme might well aim at about 4,500 MW of nuclear plant by 1965 rising to perhaps 12,000 MW by 1970. But even by 1970 the nuclear capacity would represent only 23½ per cent. of the total capacity (although it would contribute about 40 per cent. of the total electrical energy) and it is worth noting that in the five years of 1965-1970 new conventional plant would still have to be installed at the rate of 1,100 MW per annum.

Safety Systems

Speaking on the design of gas-cooled reactors in his Thomas Hawksley Lecture delivered before members of the British Nuclear Energy Conference, Sir Claude Gibb referred to automatic safety systems. Safety, which is associated with public confidence, will be a major factor in the success of Britain's nuclear power programme.

No Hazard.—It is now accepted that the gas-cooled graphite-moderated reactor does not present any hazard to the general public. Equally important, although not generally appreciated is the fact that by careful design, it can be arranged that the reactor will not suffer serious damage due to the failure of its control or main cooling systems. The prime consideration in this respect is the prevention of excessive fuel temperatures. If at any time the ratio of the heat output to coolant flow exceeds the design value, overheating of the fuel will occur. An increase in this ratio can be due either to an increase in heat output or a decrease in coolant flow. It is essential that under either condition, the rise in fuel temperature shall be a minimum.

Control Rods.—The most likely cause of increase in reactor power is withdrawal of the control rods. It is very simple to arrange the maximum rate of withdrawal so that maloperation at start-up cannot produce dangerous power surges, and the possible rate of rise of power at operating levels made such that, should automatic tripping devices fail, there would be time to make manual correction on receipt of warning given by a number of independent devices.

Coolant Flow.—Reduction of coolant flow due to a failure of the main circulators would cause a more rapid rise in fuel temperature than that due to control-rod withdrawal and particular attention must be paid to maintenance of an adequate flow of coolant at all times.

Incidents Giving Shut-Down.—Elaborate systems of protection are provided to ensure immediate reactor shut-down following such incidents as failure of main circulators, excessive gas pressure, excessive fuel temperature, and excessive power level, but when considering the inherent safety of the reactor, the reliability of the protection systems cannot be assumed.

Temperature Rise.—The most serious case to be considered is, therefore, coincident failure of the main circulators and the trip circuits. Under this condition the transient temperature rise of the fuel elements depends upon three main factors: (1) the negative uranium temperature coefficient of reactivity; (2) the run down time of the main circulators; and (3) the capacity of standby coolant plant and the natural circulation inherent in the coolant circuit design. As soon as the flow of coolant falls, the fuel temperature rises, and because of the negative temperature coefficient of the fuel, the power starts to fall. If the rate of change of flow is small enough, the power falls almost in step with it and there is only a slight rise in fuel temperature. However, the collapse of power cannot follow rapid reductions in flow and the rise in temperature can be excessive.

Circulators.—The rate of fall of flow on failure of the main circulator drives can be reduced by increase in the inertia of the main circulators. By careful design of the coolant circuit, it is possible to achieve a sufficient flow of coolant by natural circulation to remove the heat and keep the fuel-element temperature only slightly above the normal operating level when ultimately the circulators come to rest. The provision of auxiliary circulator drives which automatically take over and maintain forced circulation further limit both the maximum and final fuel temperatures.

During the transient following circulator failure, the increase in coolant temperature causes increase in coolant pressure which, if great enough, would cause the safety valves to lift. With a suitable run-down time of the main circulators, this blow-off can be prevented.

Duct Fracture.—The fracture of a main duct or other portion of the pressure circuit, with consequent loss of coolant, is a possibility which must be considered in the mechanical design of these components and, particularly with the expansion joints, long time life tests with pressure and temperature cycling are necessary before finalising design. Should failure occur, with auxiliary drives maintaining circulators at 20 per cent. normal speed, the fuel temperature can be maintained only slightly above the design value with the coolant at atmospheric pressure. With natural circulation, while the temperature rise is considerable, it is still appreciably below the melting point of the fuel cans.

General Notes

Helium Drier for DIDO

For the DIDO materials testing reactor at Harwell, which uses highly enriched uranium fuel cooled and moderated by heavy water, British Oxygen Engineering Limited has supplied a helium drier and adsorber based on the system shown diagrammatically in Fig. 4. If the hydrogen and oxygen resulting from the action of radiation on heavy water were allowed to accumulate, an explosive atmosphere could be produced in the reactor. To remove these unwanted gases and any air that may leak into the reactor, helium is employed in a closed circuit. This system requires that the helium itself is purified. A comparatively small plant was specified capable of completely removing small quantities of impurity. Since the lower the temperature the greater the adsorbent capacity, the method adopted has been to cool the helium to the boiling point of liquid nitrogen (− 196 deg. C.) and then to pass it over a special form of active charcoal. Thus a reduced volume of helium is necessary, circulating at higher velocity, and the container is correspondingly smaller.

The radioactive helium emerges from the reactor at approximately ambient temperature and is pre-cooled in an aluminium-sheathed heat-exchanger through which the purified gas is passed on its way back into the reactor. From the heat-exchanger the helium then passes to the liquid nitrogen cooler which, together with the adsorber, is encased in a stainless-steel cylinder. The adsorber is arranged in tandem for batch operation, and only one section is used at a time. Periodically, the charcoal in each section in turn has to be regenerated. This is done by a combination of an increase in temperature and evacuation of the hydrogen, nitrogen and oxygen by means of a vacuum pump. The level of the liquid nitrogen is maintained constant. Since radioactive materials are involved the entire plant, which measures approximately 5 ft. 6 in. by 10 ft., must be free from leakage; helium being the second lightest gas escapes through the smallest pinhole. In view of the low temperatures, the plant is heavily insulated.

Instrument Companies Merge

Two companies concerned with nuclear instrumentation are to merge—Isotope Developments, of Aldermaston, and R. A. Stephen and Company, of Mitcham—it has recently been reported.

Radioactive Lighting

The industrial laboratory of the Denver and Rio Grande Western Railroad has disclosed the development of a radioactive lamp that will shine for 12 years before it needs refuelling. The lamp is said to contain a radioactive gas trapped in a partial vacuum between coated lenses that can be tinted to the colours required for railway signalling.

Vulcanising by Irradiation

The vulcanising of motor tyres has been carried out at the National Reactor Testing Station, Idaho, by enclosing them in steel moulds and rotating them in a 17 ft. deep water-filled trench over radioactive fuel elements taken from a reactor. Dr. C. Stockman of the B.F. Goodrich Company is reported to have stated that, although laboratory experiments indicated that the irradiation cured tyre had from 8 to 10 per cent. more resistance to abrasion and twice as much resistance to ageing and deterioration as a conventional tyre, the cost of vulcanising in this way was at present too high and might remain so for a decade.

Neutron Chopping

Last week on page 241, we showed a drawing of the Brookhaven fast chopper. The last sentence of the caption had been curtailed with misleading results and should have read: the inertia problem with an orthodox shutter would be considerable, and a rotating principle is employed. A hole pierced diametrically through the rotating component permits passage of the neutrons as it comes in line with the inlet and outlet ports.

Lightning Conductor

Another use for radioactive techniques appears to have been discovered. It has been reported in *The Daily Telegraph* that St. Peter's basilica and the Vatican palaces are to be equipped with radioactive lightning conductors. It has been suggested that the radiation renders the air more conductive to electricity so that charges may leak away as they form, so preventing build up to a dangerous level.

Course

A vacation day (10 a.m. to 5.15 p.m.) course on nuclear metallurgy, to be held from April 9 to 12, is announced by the Department of Metallurgy, Battersea Polytechnic. Subjects to be

covered include extraction and fabrication processes, metallurgy of the trans-uranic elements, irradiation and corrosion problems, fuel-element technology and liquid metals. All lectures except the introduction will be given by United Kingdom Atomic Energy Authority specialists, including Dr. A. B. McIntosh. The fee is £10 10*s.* 0*d.* and application forms may be obtained from the Secretary (Vacation Course), Battersea Polytechnic, Battersea Park Road, London, S.W.11.

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BRIGHTER OUTLOOK FOR CARS

With the announcement of the worst production figures since 1952 came hopeful signs of recovery for the British car industry. Certainly all the distributing agents look carefree and there are several new models pending. Better news about petrol supplies for the approaching spring have started a stirring in the large factories. Vauxhall announced orders for their new 1½ litre Victor totalling over £7 million and are beginning to take back workers. Several manufacturers were stepping up production even before the Minister of Transport, Mr. Harold Watkinson, announced the petrol situation was "much easier." Rising stocks of petrol—now over 90 per cent. of normal—may make de-rationing inevitable soon after Easter. This will go more than half-way towards clearing the way for full-capacity output; the reduction of hire-purchase deposits and the seasonal upsurge in demand should do the rest.

The recovery will come none too soon. The loss of ground to foreign manufacturers during 1956 in export markets was a serious blow to the country's hopes of establishing a favourable balance in its external trade. Output last year fell by over one-fifth, exports by 13½ per cent. Yet Italy, France and Western Germany had record years both for output and exports. Volkswagen exports to Australia accounted for 5·6 per cent. of total registrations there, compared with 1 per cent. in 1954. In January, German output of road vehicles was the second highest on record and over one-fifth above the figure for December. But Continental manufacturers, with the possible exception of the French, have not been handicapped by an overnight collapse in the home market which in this country followed the introduction of petrol rationing. Nor have they suffered to the same extent through the financial policies of their Governments. In the car industry more than in most others restrictions on home demand tend to affect exports. Profit margins are tied to large-scale production; any reduction in output which involves under-employment of plant has most severe repercussions on manufacturers' ability to sell overseas at competitive prices.

British car output in January was 42 per cent. below the level of January, 1956. Output in February is likely to show a continued improvement and by the end of March should be considerable. A revival in home sales is widely expected by dealers and there is little to suggest that export demand will stop rising. Provided nothing further is done to reduce home demand, the industry should do much better this year than last.

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THE JAGUAR FACTORY FIRE

In reporting on the fire in the Jaguar factory (February 22, page 232), we stated that "the roof . . . seems to have burned very rapidly up above the sprinkler system, and burning debris, falling on stores and cars, spread the conflagration at great speed." In fact there is no sprinkler system in this factory, which the company lease from the Government. Our contributor visited the scene of the fire in order to write the article; he examined the charred remains and concluded that certain fittings, pipes, etc., were parts of a sprinkler system. This was an error for which he and we apologise.

NOTICES OF MEETINGS

Aslib

LONDON
"The Royal Society's Interest in Scientific Publications and the Dissemination of Information," by Dr. D. C. Martin. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Mar. 5, 6 p.m.*

Association of Supervising Electrical Engineers

LONDON
"Cathode-Ray Tubes and Television," by C. H. Gardner. Central London Branch. White Hall Hotel, Bloomsbury-square, W.C.1. Mon., Mar. 4, 7.30 p.m.
"Trinity House Signalling and Lighting Equipment," by K. H. Gillanders. West London Branch. 134 King-street, Hammersmith, W.6. Tues., Mar. 5, 7 p.m.
Film on "1956 A.S.E.E. Exhibition." North London Branch. 677 Green Lanes, Harringay, N.4. Wed., Mar. 6, 7.45 p.m.
Film on "1956 A.S.E.E. Exhibition"; and Discussion on "Industrial Relations." South West London Branch. Prince of Wales Hotel, Hartfield-road, Wimbledon, S.W.19. Thurs., Mar. 7, 8.30 p.m.
ILFORD
"Balu Chaung Hydro-Electric Scheme," by J. A. Hill. North East London Branch. Angel Hotel, Ilford. Tues., Mar. 5, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Industrial Uses of Magnetic Power," by T. G. Hawker. Tyneside Branch. Crown Hotel, Newcastle-upon-Tyne. Tues., Mar. 5, 7.30 p.m.
SOUTHAMPTON
"Earthing and Fault Protection," by H. W. Swann. Southampton Branch. Polygon Hotel, Southampton. Thurs., Mar. 7, 8 p.m.

Chemical Society

ABERDEEN
"Intermolecular Compounds," by H. M. Powell. Aberdeen Branch. Marischal College, Aberdeen. Thurs., Mar. 7, 7.30 p.m.
BRISTOL
"Combustion of Coal," by Dr. A. C. Monkhouse. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Mar. 7, 7 p.m.

Helicopter Association of Great Britain

LONDON
"All-Weather Operation of Helicopters: Engineering and Piloting Aspects," by P. A. Hearne and J. W. Reid. 4 Hamilton-place, W.1. Fri., Mar. 8, 6 p.m.

Illuminating Engineering Society

CARDIFF
"Lighting for Photography," by R. W. Unwin. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Mar. 7, 7 p.m.
EDINBURGH
"Lighting and Production," by J. W. Howell. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Mar. 6, 6.15 p.m.
GLASGOW
Annual Meeting. "Lighting and Production," by J. W. Howell. Glasgow Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Mar. 7, 6.30 p.m.
SWANSEA
"Lighting for Photography," by R. W. Unwin. Swansea Group. Offices of the South Wales Electricity Board, The Kingsway, Swansea. Wed., Mar. 6, 6.30 p.m.

Incorporated Plant Engineers

DUNDEE
Annual General Meeting. Recording of an address by Sir Oliver Lyle. Dundee Branch. Mathers Hotel, Dundee. Mon., Mar. 4, 7.30 p.m.
EDINBURGH
Annual General Meeting. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Mar. 5, 7 p.m.
GLASGOW
Annual General Meeting. Glasgow Branch. More's Hotel, Glasgow. Wed., Mar. 6, 7.15 p.m.
LEICESTER
Open Meeting. Leicester Branch. College of Art and Technology, Leicester. Wed., Mar. 6, 7 p.m.
PETERBOROUGH
"Development and Operation of Wind Tunnels," by D. Grundy. Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Thurs., Mar. 7, 7.30 p.m.
SOUTHAMPTON
Film Evening. Southern Branch. Polygon Hotel, Southampton. Wed., Mar. 6, 7.30 p.m.

Institute of Metals

LONDON
"Gas in Light Alloys," by Dr. C. E. Ransley. London Local Section. Thurs., Mar. 7, 6.30 p.m.*
OXFORD
"The Writing of Scientific Papers," by Dr. W. Hume-Rothery. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Mar. 5, 7 p.m.

Institute of Petroleum

LONDON
"Trends in Exploration Methods," by H. R. Warman and Dr. A. T. Dennison. Wed., Mar. 6, 5.30 p.m.*

Institute of Physics

ABERDEEN
"Research in Nuclear Physics at the University of Glasgow," by Professor P. I. Dee. Scottish Branch. Natural Philosophy Department, Marischal College, Aberdeen. Wed., Mar. 6, 7.15 p.m.
DURHAM
"Solid State Image Amplifiers," by Professor G. F. J. Garlick. North Eastern Branch. Science Laboratories, The University, Durham. Tues., Mar. 5, 5.30 p.m.*
SWANSEA
"The Recording of Faint Optical Images," by Professor J. D. McGee. South Wales Branch. University College of Swansea, Swansea. Fri., Mar. 8, 5.15 p.m.*

Institute of Refrigeration

LONDON
"Automatic Control Systems for Refrigerating Plant in Air Conditioning," by D. H. Powell. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Mar. 7, 5.30 p.m.*

Institute of Road Transport Engineers

BRISTOL
"Wheel Alignment in Relation to Tyre and Vehicle Performance," by G. H. I. List. Western Centre. Royal Hotel, Bristol. Thurs., Mar. 7, 6.30 p.m.
CARDIFF
"From the Laboratory to the Road," by W. A. Snell and T. I. Fowle. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Mar. 8, 7 p.m.
GLASGOW
"Design and Construction of a Modern Goods-Carrying Vehicle," by A. S. C. Marks. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Mar. 4, 7.30 p.m.
NORWICH
Discussion on "Mechanical Handling." Eastern Centre. Canteen, Offices of the Eastern Counties Omnibus Co. Ltd., Norwich. Tues., Mar. 5, 7 p.m.
NOTTINGHAM
"Development of the Hobbs Transmission Gear," by J. Hobbs. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., Mar. 6, 7.30 p.m.

Institution of British Agricultural Engineers

CHIPPENHAM
"Mechanical Handling and the Preparation of Feeding Stuffs on the Farm," by J. T. Taylor. Western Centre. Lackham School of Agriculture, Chippenham. Tues., Mar. 5, 7.15 p.m.

Institution of Chemical Engineers

LONDON
"Radiation from Luminous Town's Gas Flames," by S. R. Tailby, M. D. Ashton and I. Berkovitch. Geological Society, Burlington House, Piccadilly, W.1. Tues., Mar. 5, 5.30 p.m.*
BIRMINGHAM
"Project Costing in the Chemical Industry," by B. M. Robbins and H. C. Hollands. Midlands Branch. Midlands Institute, Paradise-street, Birmingham. Wed., Mar. 6, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Behaviour of Radioisotopes in Sewage Treatment and the Disposal of Radioactive Wastes to Sewers," by A. W. Kenny. Joint meeting of Public Health Division with the British Nuclear Energy Conference. Tues., Mar. 5, 5.30 p.m.*
HULL
"Nuclear Power Station Construction," by W. H. C. Pilling. Yorkshire Association. Electricity Showrooms, Ferensway, Hull. Thurs., Mar. 7, 6.15 p.m.*
LIVERPOOL
"Repair of Fire Damage at Skerryvore Lighthouse," by P. H. Hyslop and T. W. Moran. North Western Association. Central Libraries, William Brown-street, Liverpool 3. Wed., Mar. 6, 7.30 p.m.

Institution of Electrical Engineers

LONDON
"Electronics in Administration: A Survey," by Dr. D. C. Espley. Radio and Telecommunication Section. Mon., Mar. 4, 5.30 p.m.*
Film Evening. London Graduate and Student Section. Wed., Mar. 6, 6.30 p.m.*
"Cathodic Protection," by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave. Thurs., Mar. 7, 5.30 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cagodan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)

BARNSLEY
"Mine Locomotives," by T. E. Green. North Midland Centre. Town Hall, Barnsley. Tues., Mar. 5, 7 p.m.
BIRMINGHAM
Various short papers. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Mar. 4, 6 p.m.*
DERBY
"Electrolytic Processes for Surface Conditioning of Metals," by Professor J. W. Cuthbertson. East Midland Centre. Offices of the East Midlands Electricity Board, Derby. Tues., Mar. 5, 6.30 p.m.
LIVERPOOL
"Electronics and Automation: Some Industrial Applications," by Dr. H. A. Thomas. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., Mar. 4, 6.30 p.m.
MANCHESTER
"D.C. Winder Drives Using Mercury-Arc Rectifier/Inverters," by L. Abram, J. B. McBreen and J. Sherlock. North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Mar. 5, 6.15 p.m.

Institution of Engineering Designers

LONDON
"Numerical Control of Machine Tools," by O. S. Puckle. Thurs., Mar. 7, 6.45 p.m.

Institution of Heating and Ventilating Engineers

NEWCASTLE-UPON-TYNE
"Medium-Pressure Hot Water," by T. H. F. Holman. North East Coast Branch. North of England Institute of Mining and Mechanical Engineers, Westgate-road, Newcastle-upon-Tyne. Tues., Mar. 5, 6.30 p.m.
NOTTINGHAM
"Warm Air Heating and Ventilating," by G. L. Simpson. East Midland Branch. College of Arts and Crafts, Waverley-street, Nottingham. Wed., Mar. 6, 6.45 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Market Research and the Engineer." Industrial Administration and Engineering Production Group. Fri., Mar. 8, 6.45 p.m.*
CHICHESTER
"Construction of the New Woodhead Tunnel," by F. A. Sharman. Southern Branch. Assembly Rooms, Chichester. Wed., Mar. 6, 6.30 p.m.
OXFORD
"Does the Emergence of the New Nuclear Energy Industry Invite Changes in the Teaching of Heat Engines," by Dr. D. J. Allen-Williams. Eastern Branch. Rhodes House, Oxford. Tues., Mar. 5, 7.30 p.m.

Institution of Production Engineers

COLCHESTER
Annual General Meeting. "Trade Unions and Productivity," by L. Stubbs. Eastern Counties Section. Davey, Paxman & Co. Ltd., Britannia Works, Colchester. Fri., Mar. 8, 7 p.m.
CROYDON
"Recent Developments in Precision Investment Casting," by W. N. Jones. London Section. Creed and Company Limited, Telegraph House, East Croydon. Thurs., Mar. 7, 7 p.m.
READING
"Investing in Better Factory Design, Construction and Layout," by D. Myers. Reading Section. Great Western Hotel, Reading. Thurs., Mar. 7, 7 p.m. (Preceded by Annual General Meeting.)
WOLVERHAMPTON
Annual General Meeting, at 6.45 p.m. "Application of Oil Hydraulics to Production Methods," by R. G. Hamilton, at 7.15 p.m. Wolverhampton Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Mar. 6.

Institution of the Rubber Industry

LIVERPOOL
"Modern Developments in Mould Cleaning," by R. Green and W. A. Tandy. Merseyside Section. Stork Hotel, Liverpool. Mon., Mar. 4, 7.15 p.m.

Institution of Structural Engineers

LONDON
Discussion on "Building in Timber." London Gradutes' and Students' Section. Tues., Mar. 5, 6.30 p.m.
CARDIFF
"Design of Aircraft Hangars," by J. M. Burke. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Mar. 5, 6.30 p.m.
HULL
"Nuclear Power Station Construction," by W. H. C. Pilling. Yorkshire Branch. Electricity Building, Hull. Thurs., Mar. 7, 6.15 p.m.*
MIDDLESBROUGH
"Abbey Steelworks," by W. S. Atkins. Northern Counties Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., Mar. 5, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Abbey Steelworks," by W. S. Atkins. Northern Counties Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Mar. 6, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Treatment of Effluents," by Arthur H. Waddington. Fri., Mar. 8, 7 p.m.*
BIRMINGHAM
"Fuel Economy and Heat-Electric Generation," by Bryan Donkin. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Mar. 6, 7 p.m.

Royal Aeronautical Society

LONDON
Tenth Louis Bleriot Lecture. "New Methods in Aircraft Production," by Paul Badré. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Mar. 7, 6 p.m.*

Royal Institution

LONDON
"European Organisation for Nuclear Research," by Sir Ben Lockspeiser. Fri., Mar. 8, 9 p.m.

Royal Society

LONDON
"Electron and Lattice Conduction in Metals," by I. I. Hanna and E. H. Sondheimer; and "Dynamics of Twinning," by R. L. Bell and R. W. Cahn. Thurs., Mar. 7, 4.30 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Silicate and Alumino Silicate Analysis," by H. Bennett. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Mar. 5, 7 p.m.

NEW CARS FROM VAUXHALL AND AUSTIN

By Gordon Wilkins

At a time when a large proportion of European car production has independent rear suspension, and a large proportion of British cars are offered with automatic clutches, overdrives, or fully automatic transmissions, nothing could be more conservative than the new Vauxhall Victor, introduced by the British subsidiary of General Motors. It conforms with the classic American conception, scaled down to European size, and certainly gives big space for passengers and luggage with the minimum of mechanical complication. The masses are concentrated far from the centre of gravity to give a high moment of inertia, ensuring a level well-damped ride, and a strong resistance to lateral disturbing forces. Radiator, battery and nearly half of the engine are ahead of the front wheel centre; spare wheel, fuel tank and luggage locker are entirely behind the rear axle. The weakness of this formula is the large possible variation in luggage and fuel weights, which can have a marked influence on rear wheel traction and general road holding.

The unit structure is remarkably simple, except for the cranked front pillars required to accommodate the wrap-round windscreen; box section reinforcements alongside the engine curve out under the floor to join the body sills, providing sufficient stiffness to permit use of slim pillars and large glass areas above the waistline. Resistance to torsion is high; over 4,000 lb.-ft. per degree of deflection. The rear half-elliptic springs have only three leaves, and slope down to their front anchorage points, to eliminate roll steer effects at the rear. Wishbones on the front suspension have a length ratio of 2 : 3 and are arranged so that the wheels swing through an arc of 150 in. radius during suspension deflection, minimising camber changes and tyre scrub. Power from the 1½-litre four-cylinder engine has been raised 10 per cent. and torque 5 to 10 per cent. over that of the unit used in the Wyvern, by increasing compression to 7·3 : 1, and using a new cylinder head with separate inlet and exhaust ports to each cylinder. It now gives a gross 54·8 b.h.p. at 4,200 r.p.m. Gudgeon pins are offset $\frac{1}{16}$ in. towards the thrust side of the pistons; it is claimed that gas pressure about the offset axis rocks the piston as it reaches T.D.C. and produces much less noise than the usual abrupt slap against the thrust face.

Transmission is through a three-speed all-synchomesh gearbox and hypoid axle. The steering column gear shift is exceptionally compact and precise thanks to the use of the American type of concentric tube on the column. Kerb weight for the basic model is 2,140 lb., a notable achievement with the framework of orthodox design; this, together with a flat torque curve and the use of synchromesh for first gear, provides the justification to use only three speeds and a high axle ratio of 4·125 : 1.

Engineering development of the car cost £2 million, and £4 million was spent on dies, fixtures and special machine tools for its production. Already, orders in hand are said to total £7 million, and two-thirds of the 1,900 men dismissed in August, 1956, and January, 1957, have been gaken on again. Many more will be needed to take the labour force from its pre-recession total of 14,000 to the ultimate objective of 20,000.

The B.M.C. have almost simultaneously announced their new Austin A55 to replace the A50 (the A40 is no longer made). Changes to the body, a longer tail, wrap round rear window, new side decorations and hoods over the headlamps, give it a longer, lower look, and bring panel production into line with that employed for the A95. There is more space for luggage and 2 in. more knee room in the rear seats. Interior style changes include a new steering wheel. The power unit is the 8·3 : 1 compression single-carburetter version of the B.M.C. B-type engine, giving 51 b.h.p. from 1,489 c.c., and official figures show no weight increase over the previous model, at 2,240 lb. Price also is unchanged. The gearbox has four speeds and optional equipment includes both the Borg Warner overdrive and the Manumatic automatic clutch.

Another recent B.M.C. change is a switch from coil springs to half-elliptics at the rear on the Riley Pathfinder. It is a logical move as the same change has already been made on the Wolseley 6/90, which uses the same structure, and road holding is said to be improved, but it extinguishes one of the few attempts to break the uniformity of British rear-suspension design, which is becoming a vulnerable point in view of the rapid developments taking place in suspension design in Europe and the United States.

Vauxhall Victor.

Austin A55.

UPPER ATMOSPHERE RESEARCH

Royal Society's I.G.Y. Programme

Five University groups working under the auspices of the Gassiot Committee of the Royal Society, and the Royal Aircraft Establishment, are co-operating in carrying out scientific investigations on the temperature, pressure and density of the atmosphere up to the greatest attainable heights, and the variation of wind speed and direction with altitude, using instruments carried to high altitudes in the atmosphere by Skylark rockets. (The first of these rockets was fired at the Woomera rocket range, Australia, on February 13; it was a test firing and no scientific observations were made.)

TEMPERATURE FROM SOUND-RANGING

The group at the Physics Department of University College, London (Professor H. S. W. Massey, F.R.S., and Dr. R. L. F. Boyd) are proposing to measure the temperature and horizontal and vertical wind speed up to heights of 60 miles or so, using a sound-ranging method. The speed of sound in the air is proportional to the square root of the air temperature, so that from the observed variation with height of the speed of sound, that of the temperature may be obtained. Grenades will be ejected from the rocket at regular intervals to explode after about two seconds. The arrival of the sound pulse from each explosion will be timed at an array of ground-based microphones. At the same time the arrival of the flash from the explosion will be observed on several wide-angle cameras, also on the ground. From analysis of the data, using electronic computation, it is possible not only to obtain the required variation with height of the speed of sound, but also to determine the deviation of the downward-moving sound waves by the winds at different heights.

Experiments proposed by the Royal Aircraft Establishment are aimed at the determination of air pressure, density and temperature from readings of pressure gauges mounted on the nose of the rocket itself.

The wind distribution will also be studied by a group from the Meteorology Department at Imperial College, London (Professor P. A. Sheppard) using a different method. A cloud of radar-reflecting aluminium strips will be ejected at about 30 and 50 miles' height. The movement and spread of the cloud as it falls under the influence of the winds will be followed by radar.

NIGHT AIR-GLOW

There are a number of remarkable optical phenomena associated with the upper air. One of these, the polar aurora, is fairly well known, but there is a far more constant and usual sky emission called the night air-glow. On a clear night the light from the sky includes not only the sum total of star light and any moonlight, but also this faint component which is emitted from the atmosphere itself. Although this air-glow has been studied for a long time, the nature of the processes which give rise to it are far from well understood and even the heights from which the strongest emission of the different wavelengths are emitted are not known. The group at Queen's University, Belfast (Professor D. R. Bates, F.R.S., and Dr. E. B. Armstrong) is to fly instruments designed to measure the intensity of the light from the night air-glow at different heights. Certain wavelength ranges for study will be selected by suitable filters and the light intensity measured by electrical methods. The results will be transmitted to ground by a coded radio signal, during the rocket flight.

An unexpected constituent of the light in the night air-glow is the yellow light of sodium. It appears that there is about one ton of sodium in the high atmosphere, and it is by no means clear why these metallic atoms should be present and no others. The brightness of the yellow sodium emission is much greater at twilight and dawn. This is because the sunlight, which is not visible at ground under these conditions, causes the sodium, which is concentrated about 45 miles up, to fluoresce strongly. The Queen's University group propose to produce sodium yellow fluorescence artificially by ejecting a cloud of sodium at a chosen height from a rocket. This will be done, as in the first American experiments which were undertaken following a suggestion by Professor D. R. Bates, by carrying in the rocket a mixture of sodium and thermite which is ignited and ejected from an enclosing canister and thrown out. If the rocket flight is carried out at twilight the ejected sodium cloud will glow a bright yellow. By following the motion of different parts of the cloud, information can be returned about wind at the cloud height. This can be done by using the same cameras as those employed by the University College group for the grenade experiement. Furthermore, the temperature of the region occupied by the glowing cloud can be obtained by studying the widths of the sodium spectrum lines emitted. Spectroscopic studies of the glow will also help in the understanding of the different chemical processes which contribute towards the air-glow emission.

PROBING THE IONOSPHERE

The region of the upper air known as the ionosphere plays a vital part in securing the transmission of radio signals to great distances over the earth's surface. These signals would pass straight out into space without following the curvature of the earth if it were not for the ionosphere, which reflects them back to ground, provided that they are not of too short a wavelength. The main regions of the ionosphere are the E layer (about 60 miles up) and the two F layers which extend upwards from an altitude of 100 miles. These layers are effective because they contain important concentrations of free electrons and charged atoms or ions. Much information has been obtained about the layers using radio signals, transmitted and received at ground, as probes, but some information can only be obtained by using rocket-borne transmitters and receivers. Plans are being made to carry out studies of this kind by Dr. W. J. G. Beynon, of the Physics Department, the University College of Swansea, and Mr. G. Ratcliff, of the Department of Electrical Engineering, the University College of Swansea, in conjunction with the Royal Aircraft Establishment. Assistance is also being afforded by the Royal Naval Scientific Service in the provision of apparatus.

These radio experiments give information about the variation of free-electron concentration with height. They require extensive equipment and much preliminary testing, so will be made later. Equipment to obtain information about the ionosphere without use of radio signals will be flown in the rockets by the groups at the Physics Departments of the University of Birmingham (Professor J. Sayers) and University College, London. The object of these experiments is to determine not only the degree of ionisation, but also the actual types of ion present in the ionosphere. To do this the ions will be collected by equipment ejected from or projected out of the rocket, and capable of analysing the ions to determine their mass and whether they are positively or negatively charged. The results, suitably coded, will be returned continuously to ground by the radio telemetry link as the rocket ascends through the layers. All the experiments described above will form part of the United Kingdom contribution to the International Geophysical Year (July 1957-December 1958) which is being organised by the Royal Society.

BRITISH COLUMBIAN VENTURE

B.T.H. to do Power Survey: 180 *m.p.h. Monorail Proposed*

A large tract of near-virgin territory in British Columbia is to be surveyed for minerals, power resources and timber under an agreement recently signed between the State Government and the Axel Wenner-Gren Foundation. The survey stretches 470 miles northwards from Fort McLeod to the Yukon border and is up to 150 miles wide—roughly as big as Scotland and Wales together. The territory is located either side of a rift valley—the Trench—running parallel with the main chain of the Rocky Mountains, and the venture is, in many ways, reminiscent of the explorations which preceded the westward shift of settlers three and four generations ago—except that mid-Twentieth Century surveying methods are now available.

The first part of the project involves a survey, much of it from the air, in which Canadian, British and Swedish firms will participate. The cost of this survey is put at 5 million dols. and is to be completed within 18 to 24 months. Based on the findings of the survey, the sponsors then expect to construct a high-speed—up to 180 m.p.h.—monorail railway through the territory, starting from the existing terminal of the Pacific Great Eastern Railway at Prince George. The system to be used is the Alweg monorail which has been developed by another of the Wenner-Gren subsidiaries. It uses electric rolling stock carried on a single broad rail supported on pillars, the particular advantages claimed for the system being the low track maintenance required and its comparative freedom from weather hazards, especially snow.

The principal firms to be concerned in the survey work and their respective responsibilities are as follows:—

British Thomson-Houston Export Company, London, are to examine the power resources of the area, particularly the hydro-electric power available, and are also to be the electrical consultants to the Foundation. As yet there is only one water gauge station in the area. The territory to be surveyed is described as the watershed of the Peace River and its tributaries above Hudson Hope, and much of the watershed of the Ketchika River and its tributaries.

Lundberg Explorations Limited, Toronto, will undertake the mineralogical surveys and will advise on future exploitation; iron-ore, copper, silver and tin are likely to be found.

Hedlunds Travarn A.B., Sweden, will make the principal forestry surveys and will be the permanent advisers on timber matters generally.

Rankin Company, Toronto, will do the survey in respect of pulp and paper developments. At least one pulp mill, of 100,000 tons annual capacity, with ancillary sawmills, will be built.

Although it is stressed both by Government spokesmen and by the Foundation that there is as yet no real knowledge of the area, and certainly no prior information of particular valuable resources, the location of the area suggests that sufficient will be found to warrant industrial investment on a large scale. The agreement just made requires that all plans, both technical and financial, shall be sanctioned by the British Columbian Government before the Wenner-Gren organisation can begin actual development. The Foundation will, however, have the first rights of exploitation in the area. Canadians are to be given the first opportunities to work for the companies that are expected to be incorporated to exploit the area, though skilled personnel will also be brought in from Great Britain and Sweden. The agreement also specifies that townships, roads, hospitals and schools, including technical institutions, shall be built as required.

The Wenner-Gren Foundation comprises four non-profit institutions, established by the distinguished Swedish industrialist Dr. Axel Wenner-Gren, which specialise in various fields of biological and medical studies. Such profits as do materialise to the Foundation from the British Columbian venture will be used to further the work of these four institutions.

In Parliament

SAUSAGES

Another of those short interludes in the consideration of important affairs of State, which emphasise so well the essentially human side of the House of Commons, occurred last week, when, for a short time, the financial side of the House's feeding arrangements was under discussion. Sir William Steward (Conservative), the chairman of the Kitchen Committee, which is responsible for the refreshment department of the House, informed Mr. N. N. Dodds (Labour/Co-operative) that the 1956 accounts, to be presented later this month, would show that the department had paid its way. It was only the second time that this fortunate situation had arisen since 1944, the other occasion being in 1954. The bank overdraft on December 31, 1956, was £8,965, but, at that date, a sum of £3,800 was owing from the Treasury. By comparison, the overdraft at December, 1951, and also at December, 1953, had been approximately £42,000.

Mr. Dodds inquired whether the Treasury was prepared to play the game so that the prices charged to Members, and to persons who worked in the Parliament buildings, could be reduced from the high level now charged. The plea for lower prices was supported by Mr. Hugh Gaitskell, the Leader of the Opposition, who also asked that the chairman of the Kitchen Committee should give consideration to the question of quality. In particular, could the Members have some better sausages ? Sir William said that he would certainly bear these matters in mind. At the same time, in a busy month like last November, of the total amounts received from the sale of food, 15*s.* out of every pound had to be paid away in wages incurred in the preparation and serving there. In those circumstances, how could prices be reduced ?

EUROPEAN NUCLEAR RESEARCH

Substantial progress has been made in regard to the construction of both the buildings and the apparatus needed for the laboratory of the European Organisation for Nuclear Research. Mr. Harmar Nicholls, Parliamentary Secretary to the Ministry of Works, replying as a representative in the Commons of the Lord President of the Council, the Marquess of Salisbury, said that the first accelerator should be in operation in the second half of this year. Most of the components for the large accelerator had been ordered, and adequate progress was being made on its housing and experimental buildings. Recruitment was proceeding satisfactorily and the staff now numbered about 480 persons.

The research activities of the Organisation, he told Mr. David Price (Conservative), were intended to be complementary to those of the member countries, since the facilities provided would be beyond the means of most of them individually. The Council of the Organisation, in deciding its research programme, took fully into account such research as was proceeding, or which might be proposed, in member countries.

SALVAGE OF DAMAGED AIRCRAFT

Suggestions that there should be a larger measure of international agreement concerning the extension of the law of salvage to include aircraft on land, other than on the shores of the sea or in tidal waters, were put forward by Mr. S. Knox Cunningham (Ulster Unionist). He was told by Mr. Harold Watkinson, Minister of Transport and Civil Aviation, that the Council of the International Civil Aviation Organisation decided in 1948 and 1949 that a pre-war draft convention was unsuited to modern requirements. Since then, the subject had remained on the work programme of the Organisation's legal committee, but no progress had been made.

Meanwhile, most States had established Government search and rescue organisations as a humanitarian service, leaving the salvage of the property to be arranged by the owners of the aircraft. It was not considered that there was any need for the Organisation to be urged to give the subject early attention.

RAILWAY CONTRACTS

Miss Elaine Burton (Labour) pressed the Minister of Transport to give a general direction to the British Transport Commission that the needs of localities, where there is at present unemployment and unused productive capacity, should receive special consideration in the placing of contracts in connection with the modernisation programme of British Railways. She pointed out that in her constituency, Coventry, there were several firms capable of building Diesel engines and railway carriages. The Daimler Company, Limited, were about to leave a Government-owned factory, suitable for such work, owing to the lack of orders, while the Armstrong-Whitworth Aircraft Company, Limited, would shortly have to turn away 600 of its workpeople. Sheds were available at Baginton.

Mr. Watkinson said that he did not propose to give such a direction to the Commission, which, in placing orders, must have regard to the experience of the suppliers and to the need to secure timely deliveries. Other things being equal, the Commission was always ready to consider placing orders in Development Areas, or in other places where unemployment presented a persistent problem, and where suitable facilities existed. He would, however, carefully examine the situation mentioned by Miss Burton.

JAPANESE FLOATING FAIR

Attention was drawn by Mr. S. S. Awbery (Labour) to the Japanese Machinery Floating Fair, consisting of a vessel of 10,000 tons, which had been refitted for the purpose, and which, he said, was travelling around the countries of South-East Asia exhibiting Japanese machine tools and machinery of all kinds. The Japanese attributed very great importance to the markets in South-East Asia and had already doubled their 1939 production. Had the President of the Board of Trade, he inquired, considered adopting similar methods to exhibit British manufactured goods in that and other areas ? Mr. Derek Walker-Smith, Minister of State to the Board of Trade, said that, when similar proposals had been examined in the past, it had been found that British industry did not consider a floating exhibition to be the most effective way of displaying their goods and, consequently, were unlikely to give adequate support. The Department's commercial officers in South-East Asia were reporting on the results achieved by the Japanese venture and he would seek the views of the Exhibitions Advisory Committee on their reports. There were, of course, a number of difficulties and disadvantages connected with that form of exhibition.

1959 Commonwealth Trade Fair ?

The President of the Board of Trade was urged by Captain H. B. Kerby (Conservative) to take the lead in initiating a Commonwealth Industry and Trade Exhibition in the summer of 1959, to focus attention on the importance of Britain's export trade, and on the market and resources of the Commonwealth. On this point, Sir David Eccles said that, while he fully agreed with Captain Kerby about the importance of developing Commonwealth trade, he considered that Britain's available resources for this purpose were better used in taking part in exhibitions in Commonwealth countries.

Commonwealth Trade Preference

In reply to a question by Mr. H. Hynd (Labour), who desired information respecting the preference enjoyed by Commonwealth countries on their exports to Britain, Mr. Walker-Smith said that almost all Commonwealth exports to this country were admitted free of protective duties and that, in addition, many of the goods of Commonwealth nations had the benefit of a tariff protection over foreign products. Exports from the United Kingdom to Commonwealth countries did not enjoy a corresponding exemption from protective duties, but a large proportion of them enjoyed significant and, in some cases, substantial, margins of preference. The Government did not measure reciprocity in trade matters on an industry-by-industry or country-by-country basis, but looked at the totality of the nation's trade as a whole.

International Geophysical Year

A number of Government Departments and research organisations in Britain, Mr. Harmar Nicholls said, were participating in the programme of research planned to commemorate the International Geophysical Year, in such fields as those of meteorology, geomagnetism, oceanography and the ionosphere. He told Mr. E. G. M. Fletcher (Labour) that a substantial grant-in-aid was also being provided from public funds through the Royal Society in support of the activities of non-Government bodies. These activities included the dispatch of a Royal Society expedition to establish a scientific base at Halley Bay on the Antarctic mainland, and a programme of research into the upper atmosphere by the firing of high-altitude rockets from the Ministry of Supply ranges in Australia. (See also page 286.)

40 m.p.h. on the Roads

Answering Lieut.-Colonel Marcus Lipton (Labour), about the measure of agreement by local authorities in the London area to proposals for increasing the road speed limit to 40 miles an hour, Mr. G. R. Nugent, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that, out of 67 authorities consulted, 49 had agreed to this limit on certain roads in their areas.

Engine Exhaust Fumes

The Medical Research Council are continuing their researches into the nature of the fumes from engine exhausts and their effects on people in built-up areas and in confined spaces. Mr. Dennis Vosper, the Minister of Health, told Mr. N. N. Dodds (Labour/Co-operative) that, so far, no evidence had been obtained that these fumes produced either immediate or long-term effects on the health of persons exposed to them in city streets. The results of the Council's investigations would be published in the scientific Press as they became available.

Cost of the Forth Road Bridge

The Secretary of State for Scotland was urged by Mr. W. W. Hamilton (Labour) to give an assurance that any increase in the ultimate cost of the Forth road bridge, above that of the current estimation, would be wholly borne by the Government. Mr. John Maclay replied that the local authorities concerned in the erection of the bridge and the Government would contribute £500,000 and £4,650,000, respectively, to the approved cost of the bridge and that the balance would be advanced by the Government by way of loans which would be repayable from the proceeds of tolls.

Petition on Roads

Among the petitions recently presented to Parliament was one handed in last week by Mr. W. Teeling (Conservative) asking for a special road loan to be raised to provide the funds for the early completion of adequate modern roads in Great Britain. Mr. Teeling said that the petition had been signed by more than 119,000 persons, resident in the South Coast area and in other parts of Great Britain. It showed that there was an urgent need in these areas for improving road communications and that the delay in carrying out such improvements was detrimental to the wellbeing of those districts and of the country as a whole.

The petitioners desired that the loan should provide the necessary funds during the period required to carry out this essential work under a comprehensive and scientifically-planned scheme, so that the delays and frustrations which have proved to be inevitable under the present system of financing road works by means of annual grants, should be avoided.

THE HUMAN ELEMENT

Clearing the Dog's Bad Name

A conference is to be held in Manchester on March 7 to remove misconceptions about the limitations of work study. It is taking place under the auspices of the joint north-west region of the Society of Industrial Engineers and the Work Study Society and is the first major event staged by these two bodies since their fusion. Papers will be given by a group of industrialists and experts on work study.

Few dogs have taken longer to lose their bad name than time and motion study. Work study is a wider subject than time and motion study and indeed the greater includes the less. But there have been plenty who have seen " work study " as no more than a respectable title for the old game of rate cutting. There is a double prejudice here. Time and motion study has graduated from its early crudities although it can still be misused by those who have a mind to do so. Second, work study is much more than time study since it includes method study. It is possible to have method study, and achieve much from it, without going anywhere near a stop watch or a rating system concerned with incentives.

A conference to remove prejudice on this subject could not have a better place than the north-west. Engineering, where work study in all its aspects has made more progress than in any other industry, is now as important to Lancashire as cotton textiles. So far as cotton textiles are concerned, it is a fair guess that systematic work study in the mills could do more to save the industry than any other one factor. It is high time to marry the experience of the one industry to the need of the other.

Employees' Vested Interest

Employees are not very interested in company profits or what is done with them. Beyond their own salaries or wages—and those of their friends and neighbours—there is little concern with the broader problems of company finance. Yet they are keenly interested in new developments and the trading prospects of their company. These conclusions were reached in a report published last week by the British Institute of Management entitled *Presenting Financial Information to Employees*.

The report contains the detailed results of seven case studies and those of a B.I.M. survey of 89 companies giving financial information to their employees. It also contains a comprehensive review of the methods which are used in this country and overseas for the disclosure of such information together with an assessment of its effectiveness and value. Some guidance is given, illustrated by views of both management and employees, as to what is practicable and desirable " bearing in mind the purposes which the giving of information fulfils." The result is a most useful and interesting review of public relations within industry.

A memorandum issued by the T.U.C. and given as an appendix to the report, emphasises the trade unions' interests in fully disclosure of information, pointing out that " only frustration and perhaps cynicism can result from secrecy and restriction." The T.U.C. advocate a much more open attitude, particularly on the part of those private companies which are not obliged to file their accounts with their annual return.

The results of the case studies are most instructive: in six out of seven companies, between 32 and 53 per cent. of employees interviewed stated that they were interested in " news about new developments and whether trade is getting better or worse."

Rather fewer were interested in " profits and what is done with them," and these ranged between 3 and 18 per cent. Despite this the report concludes, rightly in our view, that the main objective of giving financial information is " to foster an understanding of the company's affairs which will help to identify his own interests with the company's continuing success."

Patchwork in Shipbuilding

Good labour relations are built up on trust and clarity of meaning. There is a perpetual temptation for employers to be clever in negotiation and for union representatives to be doggedly unimaginative. This usually springs from the fact that management is the more nimble witted (but not always so) while the unions have an acute awareness of what is best for their members when it comes to Friday. From such a situation there can arise endless misunderstandings. Trust can only be built up over a period of time and depends on both sides being absolutely sure what the other exacts from an agreement. The meaning of an agreement is even more important than the agreement itself.

An example of this comes from Cammell Laird. Two weeks ago the United Society of Boilermakers threatened to strike at Birkenhead over the payment of lieu rate on " stand-by " work. This lieu rate was to be paid in place of piece-work earnings. No one but the parties concerned can know the rights and wrongs of the situation but there was clearly a misunderstanding. The belligerency of the union suggested that this strike would be a continuation of the one which lasted six weeks three months ago. To union representatives in such a frame of mind a strike has almost a corporate entity. It goes on and on like Tennyson's brook—only the babble is softened from time to time.

The boilermakers agreed after several days to go back to normal work. Last week the fitters came out on a bonus dispute. Some basic clear thinking and the establishment of clear principles by both sides seems rather overdue.

Surgical Spirit

There is no doubt that the doctors are determined to make a full-blooded operation of their pay dispute with the Ministry of Health. There seems a likelihood that the specialists will not join in the fight if extreme action is taken, but apart from that the doctors have kept their ranks undivided. The B.M.A. is being forced increasingly to look like a trade union and the thought of their organising strike action, whatever name may be used for it, is hardly an edifying one. Others may think that if there had to be a show-down between the Government and the professional point of view it might as well be the doctors. They are better organised than most to deal with the situation. The fact is, that the longer this dispute goes on, no matter who wins, the doctors are going to come out of it more as craftsmen and less as professional people than when they went in. The day that saw the health service equipped with capitation fees for medical men saw the beginning of erosion into their professional status.

This gradual change of status is seen in the attitude to the proposal for a Royal Commission to look into the matter of remuneration. This is an odd way, the profession has said, to settle a pay claim. So it is if you are an organised wage earner. There was a time, however, when the doctors would have preferred the dignity and temporary discomfort of such a device than a fight to make a government department keep to what they think is a bargain.

There is still one safety valve for all concerned if a compromise cannot be reached in the next few weeks. Resignation from the health scheme requires three months' notice. That should allow tempers to cool on both sides.

Problems of Teaching Cleanliness

A pamphlet has been issued by the Ministry of Education on health education. It ranges over a wide field from the importance of habit forming in cleanliness to smoking and sex education. The motive of those who have sponsored it is admirable but it raises a host of basic questions which a Ministry of Education is ill-equipped to answer. It puts a severe strain on the teacher who is often ill prepared to sustain it.

The pamphlet stresses the importance of home environment in early years. Teachers have not a great deal of difficulty in co-operating with parents while a child is young and where the home influence is good. In later years the situation becomes more difficult. Stress is rightly put on the variety of influences which work on a child earlier than used to be the case. Television is obviously a medium for ideas of mixed worth to children and adolescents. The question of sex education is to-day a controversial question. The pamphlet favours parents and teachers telling the truth when the awkward questions are put and few would now disagree with this—though opinion might still differ on how much of the truth to tell and when.

Sex education is largely a question of imparting knowledge at the right time. To few people, in this context, is it a moral issue though it clearly becomes so once the adolescent is armed with knowledge. The pamphlet also embarks on alcohol and smoking. These are questions to be approached with circumspection. Teacher and home can easily clash here. Are schools to teach the virtues of moderation—which is an adult rather than adolescent conception? Are the young to be frightened into not smoking for fear of cancer? Are they to be worried by seeing their parents' habits? Pedagogy run riot could do endless harm.

Peace for the Concierge

A French institution is being mechanised: in the near future tenants and their visitors will be able to enter their blocks of flats when the door is closed late at night simply by pressing a bell-knob. This will actuate an automatic door-opening device and there will be no need to rouse the unfortunate *concierge* by rings, shouts or persistent hammering.

The reasons for so radical a departure from past practice are hard to fathom. The *concierge* is generally quartered in a dark and miserable cell at the entrance of the building. She is responsible for cleaning common entrance halls, corridors and staircases, and for distributing the mail left with her by the postman. She sees everyone come in and go out. She knows the tenants' habits, visitors, and even who writes to them. Among those who prize her services are the police and the private detective. Now there will be a vital gap in her vigil. There is little doubt that many Frenchmen will rejoice, and women also. They will see in the Bill which proposes this measure, not a humanitarian measure to safeguard health, but a shrewd move to destroy what is described as the " social and perhaps political influence " of the *concierge*.

To the uninitiated, automatic devices may seem an expensive method compared to front door keys, allied to apartment bells for visitors. This is no revolutionary change but a gradual one: France does not change, only governments come and go with rapidity. The *concierge* will retain much of her sway over her flock, and her favours will still be worth a great deal. The next move might be " better housing for the *concierge* " and the exchange of the front-door lodge for a basement flat.